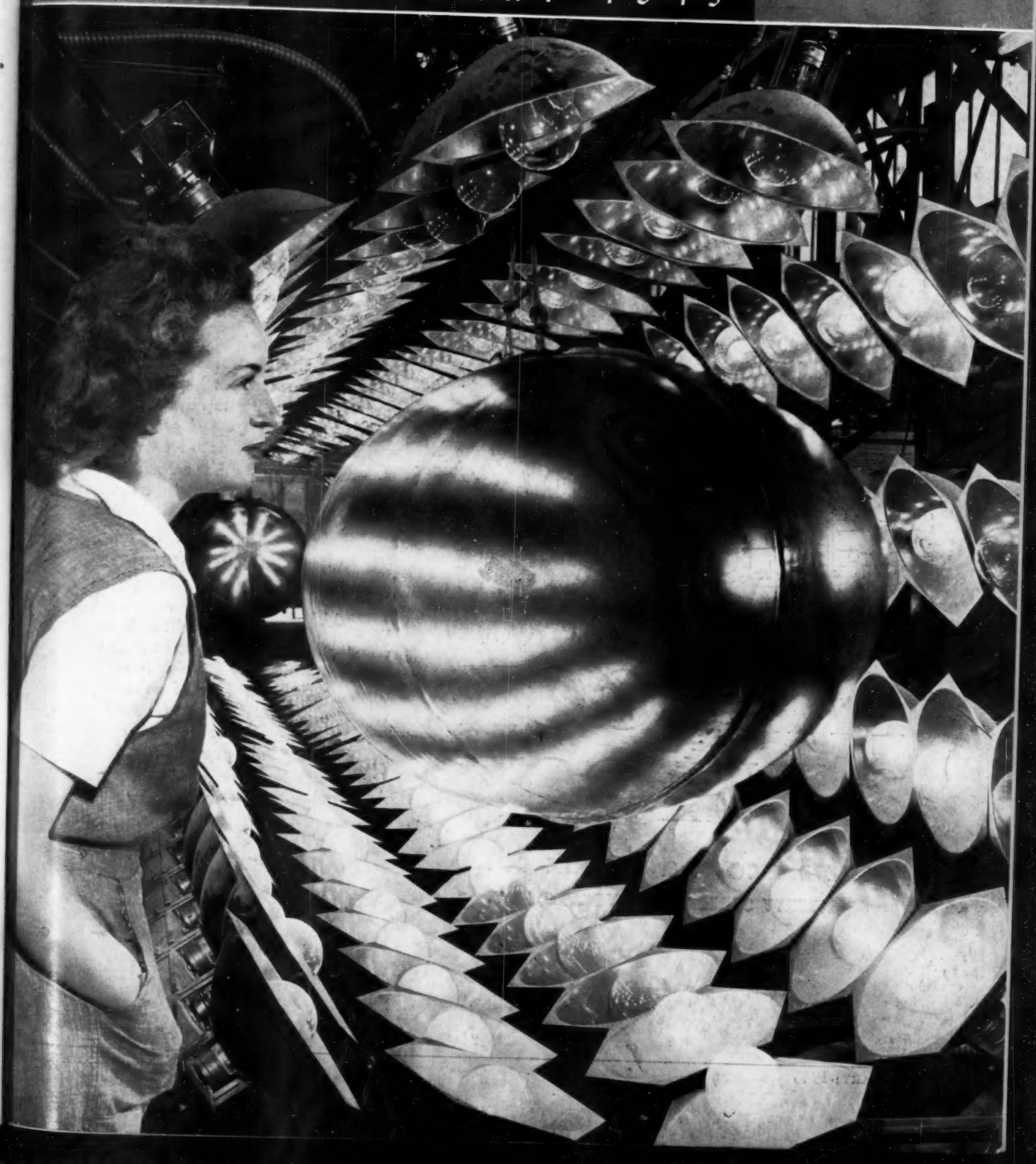
FEB 7 1945

MECHANICAL ENGINEERING

FEBRUARY 1945



Victory Will Mean New Jobs *for* STEAM

Steam will blow the whistles when the big news comes. But, in heralding the great day, steam will have done far more than sound the signal for rejoicing.

Beyond steam's part in victory . . . beyond its record of powering ships, trains, war plants, there will be thousands of stories of men . . . *engineers* . . . men with trigger minds instead of trigger fingers . . . who tackled power plant problems with keen resourcefulness so that power for war needs would never be "too little or too late". With the end of hostilities will come new Victory jobs for steam . . . new problems . . . keener competition that will put emphasis on operating costs.

With today's accelerated experience yielding more complete answers to such problems as behavior of metals at high temperatures, action of fuels in slag-tap and dry-ash furnaces, circulation in high-capacity high-pressure boilers, separation of steam from water in boiler steam drums, and other related problems, the boilers of tomorrow will be even better able to serve industry.

Building boiler units complete with all essential components . . . controlling both the design and the application of the equipment fabricated . . . these, plus extensive facilities, give us at B&W a background that's unique. As a result our engineers have at their disposal an array of boilers from which to meet any combination of conditions of capacity, pressure, temperature, feedwater, fuel, and space. Now is a good time to consult with us regarding your steam plant requirements for the future.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.

85 LIBERTY STREET, NEW YORK 6, N. Y.

Army-Navy "E" flags have been awarded to five B&W plants and also the Maritime Commission Award flags to the Barberton, Ohio, Plant.

G-279

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 67 NUMBER 2

Contents for February, 1945

THE COVER . . . . *Drop-Off Fuel Tanks Ride Conveyer Through Infrared Lamp Tunnel Courtesy of Weber Showcase Company*

MECHANICAL PROPERTIES AND USES OF WOOL FELT . . . . . *W. H. Lehmberg* 93

THEY HELP TO MAKE ENGINEER OFFICERS . . . . . *H. R. Ricardo* 100

SOME RECENT DEVELOPMENTS IN ENGINEERING MATERIALS . . . *Archibald Black* 101

TRENDS IN THE USE OF WELDED MACHINERY PARTS . . . . . *E. J. Charlton* 109

REPLICA METHOD FOR EVALUATING FINISH OF A METAL SURFACE . . *H. K. Herschman* 119

SOME ENGINEERING PROPERTIES OF NICKEL AND HIGH-NICKEL ALLOYS . . . . . *B. B. Betty and W. A. Mudge* 123

A.S.M.E. HEAT TRANSFER DIVISION 130

ENGINEERS-IN-TRAINING . . . . . *C. F. Scott* 134

EDITORIALS 91

COMMENTS ON PAPERS 136

A.S.M.E. BOILER CODE 137

REVIEWS OF BOOKS 140

A.S.M.E. NEWS 142

CONTENTS OF A.S.M.E TRANSACTIONS . 152

INDEX TO ADVERTISERS . . . 132

OFFICERS OF THE SOCIETY:

ALEX D. BAILEY, *President*

K. W. JAPPE, *Treasurer* C. E. DAVIES, *Secretary*

PUBLICATIONS STAFF:

GEORGE A. STETSON, *Editor* FREDERICK LASK, *Advertising Mgr.*

K. W. CLENDINNING, *Managing Editor*

COMMITTEE ON PUBLICATIONS:

E. J. KATES, *Chairman*

L. N. ROWLEY, JR. H. L. DRYDEN

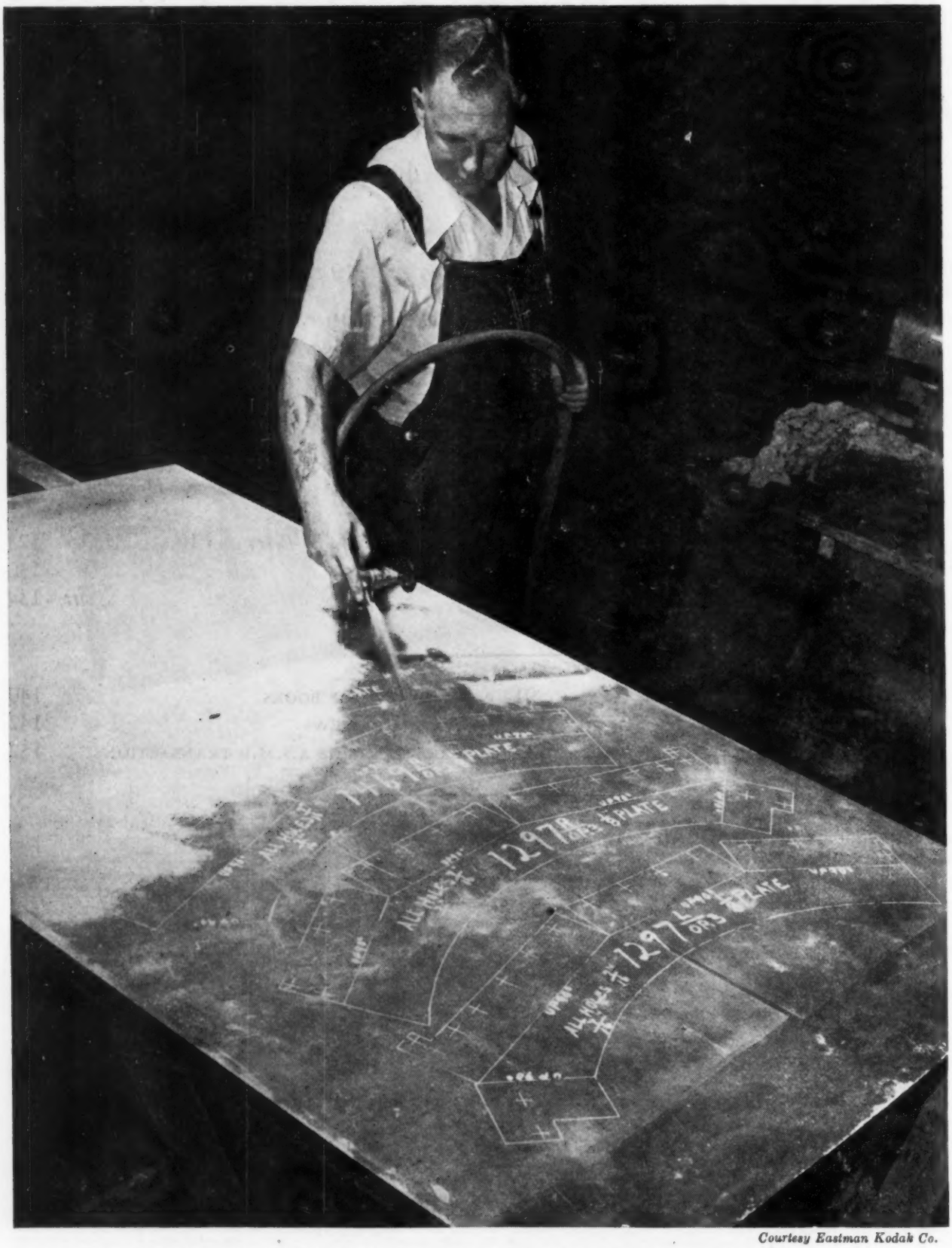
W. A. CARTER J. M. JURAN

ADVISORY MEMBERS OF THE COMMITTEE ON PUBLICATIONS:

N. C. EBAUGH, GAINESVILLE, FLA. O. B. SCHIER, 2ND, NEW YORK, N. Y.

Junior Members: RICHARD S. BIDDLE, NEW YORK, N. Y.; JOSEPH M. SEXTON, NEW YORK, N. Y.

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York 18, N. Y. Cable address, "Dynamic," New York. Price 75 cents a copy, $6.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage outside of the United States of America, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1945, by The American Society of Mechanical Engineers. Member of the Audit Bureau of Circulations. Reprints from this publication may be made on condition that full credit be given MECHANICAL ENGINEERING and the author, and that date of publication be stated.



Courtesy Eastman Kodak Co.

Simplified Method of Printing Working Drawings Directly on Metal

(Gentle water spray removes all layout paint which has been light-struck, leaving only lines of original drawing.)

VOLUME 67
No. 2

MECHANICAL ENGINEERING

FEBRUARY
1945

GEORGE A. STETSON, *Editor*

Charles F. Scott

SHORTLY before his death on Dec. 17, 1944, Charles F. Scott, fellow A.S.M.E., prepared and discussed with his friends the article "Engineers-in-Training," which will be found on pages 134-135 of this issue. No piece of his writing reveals more clearly than this does one of the dominant traits of Professor Scott's character—the intense concern he felt throughout his long life for young engineers. At the age of eighty his mind was continually on the alert for new ideas which he welcomed with a limitless zeal to explore, and test, and put into action; and his methods were based on the belief that to build a better profession it is necessary to arouse the engineer's interest early in his career. The explanatory article on engineers-in-training, to which he gave the subtitle, "An Innovation of Far-Reaching Significance," demonstrates the breadth of his vision, the practicality of his methods, and, above all, his interest in the welfare of young engineers.

It was Scott's good fortune to have begun his professional career at a time when the electrical industry was emerging into prominence and importance. His contributions to this industry are well known and will not be recounted here. He was associated with that extraordinary genius, George Westinghouse, and with the electrical engineers who aided him in the development of alternating-current machinery. The debt Scott owed to Westinghouse he discharged with a lifelong loyalty to the man and his memory. Some of Scott's last conversations were about means by which adequate and lasting recognition of his former employer could be assured. Many A.S.M.E. members will recall the dramatic session Scott staged during the 1936 Annual Meeting of the Society in connection with the commemoration of the ninetieth anniversary of the birth of Westinghouse, when a dozen or more former employees and associates of that distinguished engineer recounted personal reminiscences of him and his work. It is difficult to understand how critics of American enterprise and industrialists could have listened to the testimony Scott adduced from the speakers on that occasion without a blush of shame for their blindness and cynicism. Scott's penetrating faith in the good in men and situations that day convinced many a person, of lesser imagination and nobility of character, of the enduring contributions to the American way of life made by engineering leaders.

Few engineering organizations failed to feel the direct influence of Scott's personality and abundant energy. It was Scott and Calvin W. Rice, for many years until his death Secretary of The American Society of Mechanical Engineers, who aroused the interest of Andrew Carnegie in providing the funds with which to build the Engineering Societies Building and the Engineers' Club in New York. Scott was responsible for the formation of student branches of the American Institute of Electrical Engineers. He inspired that remarkable study of engineering education made by the Society for the Promotion of Engineering Education. His great work for unity in the engineering profession through his activities in the Engineers' Council for Professional Development was reviewed on this page in the December issue. To the cause of registration of engineers he devoted many of his later years, serving as first chairman of the Connecticut State Board of Engineering Examiners and as president of the National Council of State Boards of Engineering Examiners. In this work he was the antithesis of the typical bureaucrat. When a candidate for registration, who had satisfactorily passed the examinations and yet had failed to be registered for lack of "qualifying experience," questioned the action of the board, Scott asked himself and his colleagues what was meant by this term and set about to explain it. And when the proposal was made that young engineers be permitted to pass examinations for registration when the subject matter was fresh in their minds, so that they could be certified as "engineers-in-training," he undertook to prepare the clarifying statement published this month. It was this approach to questions that was typical of Scott. No worshiper of empty forms and outworn traditions, his patient reasonableness went straight to the heart of problems. The spirit as well as the letter of the law and the means as well as the ends themselves were his concern.

When Scott went to Yale University as head of the department of electrical engineering he brought with him not only the rich experiences of industry and engineering practice but also the background of the work he had done with young engineers and their educational and adjustment problems at Westinghouse. With his retirement in 1933 Scott moved from the Dunham Laboratory to a room in the Strathcona tower. His official responsibilities ceased, but his time was devoted to the E.C.P.D., the alumni interests of his alma mater, The Ohio State University, the counseling of the undergraduate editors of the *Yale Scientific Magazine*, and the affairs of the Yale Engineering Association. Back and forth from New Haven, to New York, Pittsburgh, and Columbus he traveled with tireless zeal. He was almost always in attendance at meetings of the societies and organizations with which he had been associated all his life. Wherever he went he took part in discussions. His habit of "thinking out loud" was familiar to those who knew him well. The strange attitudes of his long spare body and the gestures of his arms and hands as he talked, in public or in private, were outward signs of a mind seething with ideas and working under the lash of enthusiasm and strong conviction. Ideas and phrases that had been emphasized with a spiral forward movement of the hand

in these informal conversations appeared in the written text underlined, set off in quotes, or in capital letters. A patient and sympathetic listener who later read the completed document felt well rewarded for any encouragement or suggestions he had been able to offer to the thought processes of this dynamic person.

Modest, untiring, patient, and unselfish, Scott possessed the spirit of the idealist and the mind of a realist. He stripped problems of pettiness and saw them in their larger potentialities. His active mind detoured tangles of red tape, discouragement, and indifference, discounted jealousies that obstructed unity and co-operation, and made the direct approach toward ultimate goals. His spirit remained youthful and bouyant to the end. He was without guile and without malice. In his death the engineering profession has lost a noble and extraordinary character, but much of the work he started for the benefit of his fellow engineers will continue for years to come.

A.S.M.E. Heat Transfer Division

PROFESSIONAL divisions of The American Society of Mechanical Engineers are, in certain respects, technical engineering societies within the framework of the main society. Under the general supervision of the Committee on Professional Divisions, each division has its own executive committee and may set up subcommittees, advisory groups, and liaison representatives who tie in their interests with those of other divisions and committees. Each division prepares the programs of sessions it sponsors in connection with Society meetings; and in some instances professional divisions conduct national meetings of their own. Subject to the approval of the Committee on Professional Divisions, a division operates according to By-Laws and procedures which fit its particular conditions and requirements. Great latitude in operation is permitted and hence great differences exist. An exposition of the development, objectives, organization, and operation of the A.S.M.E. Heat Transfer Division will be found in this issue, pages 130–133.

Every A.S.M.E. member has the privilege of indicating his interest in the work of the Heat Transfer Division and the key letter K following the names in the Membership List let other persons know of this interest. Other key letters indicate the member's other interests and the order in which these letters are placed indicates, in general, the order of the member's interest in the various divisions. Owing to limitations of space on the addressograph plates at Headquarters, it is possible to tab the plates with only a few of the major interests, but if the Heat Transfer Division wished to reach all members whose major interest was in this field (for example, to send out notices of a special Heat Transfer meeting or publication) selection of the names of members to be addressed would be complete and automatic. Thus the members "registered" in the division would be segregated from all others on the list of Society members.

Aside from the relatively few members who serve or have served on the committees of the professional divisions, probably very few know how the divisions in which they are registered operate or have any conception of the amount of work carried on by the divisions. Consequently, they are unable to appreciate the extent of the debt they owe to their fellow members who bear the responsibility of conducting the division's affairs. The story of the Heat Transfer Division not only tells how the division is organized and operates, but also reveals what an immense amount of work is done by committee members in their service to the Society.

The A.S.M.E. Heat Transfer Division, although young in years, is making history and traditions that parallel in essential pattern those of the parent Society itself and of many other older divisions and committees.

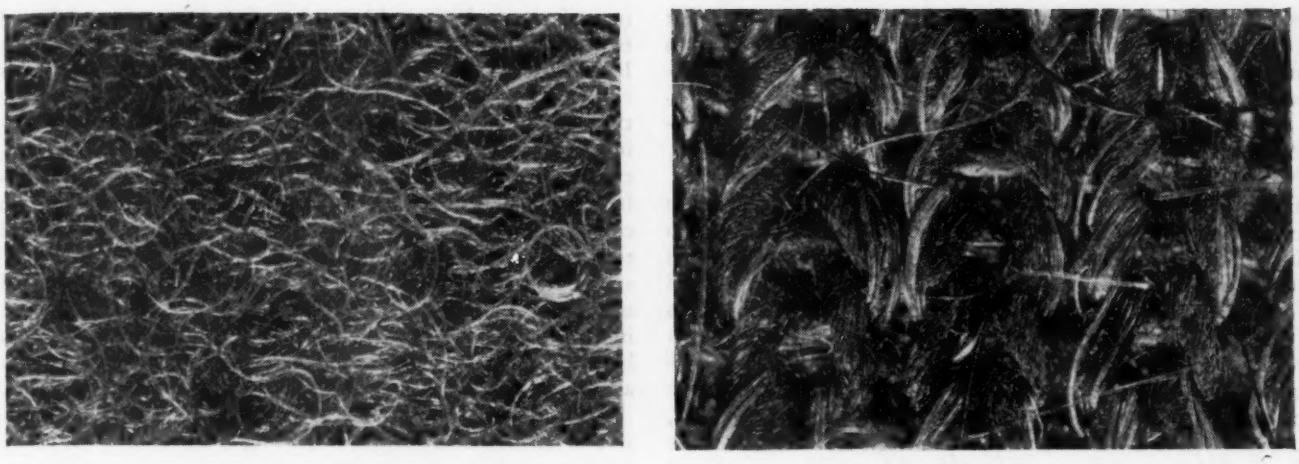
By creating a professional division within the A.S.M.E. instead of setting up an independent engineering society the organizers acted wisely. The subject of heat transfer cuts across almost every activity in mechanical engineering, and engineers whose specialty lies in the field of heat transfer are members of organizations which have broadly interconnected interests. As a division of the larger Society, these engineers do more than interchange information of direct value to them; they fertilize other fields than their own, and they reap where others have sown.

Professional Engineering

THE oft-quoted definition of engineering written by Tredgold more than a century ago for The Institution of Civil Engineers is satisfying to engineers because it is brief and general. To be sure it was followed by a category of works to which the engineer gave his attention and these probably covered the field fairly adequately at the time they were set down. But when engineering is defined for legal purposes, as, for example, in the "model" registration law, the inadequacy of definitions satisfactory to engineers is sometimes questioned by the courts. Such a situation developed recently when the Illinois act for the registration of professional engineers was declared unconstitutional by the courts. In an article in *The Registration Bulletin* for December, 1944, published by The National Council of State Boards of Engineering Examiners, D. B. Steinman reviews, with a view to improvement, the legal definition of professional engineering.

After developing the considerations which should guide the formulation of a revised definition, Mr. Steinman submits the following definition of professional engineering "for study and discussion."

"A person shall be construed to practice or offer to practice professional engineering, within the meaning and intent of this act, who, by verbal claim, sign, advertisement, letterhead, card, or in any other way represents himself to be an engineer, with or without any qualifying adjective, or through the use of some other title implies that he is an engineer; or who holds himself out as able to perform, or who does perform, any professional service of consultation, investigation, evaluation, planning, design, supervision of construction, or supervision of operation, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works, or projects, when such professional service normally requires professional training in the application of mathematical and physical sciences."



(*a*) (*b*)

FIG. 1 PHOTOMICROGRAPHIC COMPARISON OF WOOL FELT WITH KNITTED WOOLEN FABRIC
(*a*, Wool felt: S.A.E. F-1 surface; ×15. *b*, Knitted fabric surface; ×15.)

MECHANICAL PROPERTIES *and* USES *of* WOOL FELT

By W. H. LEHMBERG

THE FELT ASSOCIATION, INC., NEW YORK, N. Y.

INTRODUCTION

WOOL felt is one of the oldest of modern engineering materials. Associated by centuries of use with clothing, footwear, and miscellaneous applications of comfort and protection, its adaptable range of densities from soft to hard, and the fact that it is resilient, durable, and will not ravel when cut, are the innate characteristics responsible for its traditional position among natural materials.

In step with technological advancements within the past generation, wool felt has been employed extensively as an intermediate or nonstructural engineering material and has earned a place of growing importance among yieldable substances in mechanical engineering. Under the pressure of war production, the mechanical uses of felt have been further expanded, and certain of its properties have been improved by the supplementary treatment of finished felts. Developments of this type, coupled with engineering and research in modern felt laboratories, are opening broader fields of usefulness for mechanical felt products and invite attention to the origin, construction, and physical properties of this basic material.

DEFINITION OF WOOL FELT

Wool felt is by definition "a fibrous material built up of interlocked wool fibers by mechanical and chemical action, moisture, and heat. The blend may consist of wool and other fibers."[1] Accordingly, wool felt is distinguished from various materials fabricated from matted mineral or vegetable fibers as well as materials having a paper base and an adhesive-backed soft matted surface to which the name of felt is often applied. It is also distinguished from woven materials having a felted nap, such as papermakers felt, and all textile products in which the fibers are drawn into parallelism, spun into yarns, and then interlaced by weaving. Whereas the textile process systematically bends and twists the fibers then crosses them in tension, the felting process induces the movement of individual fibers throughout the mass and utilizes the natural crimp and interlocking characteristcs of the wool fiber. Because felt is constructed of animal fibers in their natural state, it is also distinct from those intermediate substances which are produced by methods of molecular reconstruction or polymerization. The properties of wool felt and the many uses to which it lends itself are the natural properties of the wool itself, adapted and improved by fiber blending and felt processing. A visual comparison of the structural composition of wool felt with woven and knitted fabrics is made in Fig. 1.

MATERIALS USED

Felt manufacture embraces the expert knowledge and use of more different kinds of fiber than any other single branch of the textile industry. In this respect, Table 1 is of interest as a raw-stock type classification of the wool-felt industry for the year 1942. Because wool possesses the felting ability in greater degree than any other natural or artificial fiber, many grades of felt are composed of wool exclusively. Virgin wools as well as reprocessed wools are employed. The by-products of the wool-textile industry such as noils, card waste, tops, and thread wastes are used to advantage in felts produced for various purposes. Where low cost is a requirement, re-used wools may be introduced in the raw-stock blend.

To attain specific properties in certain felts, nonfelting vegetable and synthetic fibers are added in the blend with wool as the matrix. So great is the felting power of wool that percentages as low as 20 per cent may be used on occasion. Cotton combines to attain decreased felt density or to obviate voids in

[1] The Felt Association, Inc., definition of wool felt.

Contributed by the Textile Division and presented at the Annual Meeting, New York, N. Y., Nov. 27–Dec. 1, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

wool-base filter felts; rayon, silk, and aralac to modify felt construction or surface texture. Kapok-wool combinations make possible the low thermal-conductance and high sound-absorption coefficient ratings of insulation felts.

From the standpoint of fiber fineness and length, felt is fabricated principally from fibers having a staple length of $1^1/_2$ in. Noils in the range of $^3/_4$ to 1 in., however, are not uncommon. Fibers of excessive length tend to mat without felting, while extremely short fibers lack the depth of penetration necessary to impart the tensile strength and splitting resistance required in many felt applications. A range of fiber diameters is employed for various felt types and qualities running from the fine 80's (U. S. Department of Agriculture Wool Grade Standard) down to the coarser carpet grades and cattle or goat hair used in plate-glass-polishing felts. Although fiber grade and composition by no means determine the entire character of the finished felt, the selection and blending of appropriate grades and types is the first and the most important step in the manufacture of any mechanical felt to a specific end-use performance specification.

TABLE 1 RAW-STOCK TYPE CLASSIFICATION OF THE WOOL-FELT INDUSTRY FOR THE YEAR 1942

Type of raw stock	Per cent of total fiber processed
Wool, reprocessed and re-used	33
Wool, virgin (48 types)	18
Noils, noble and French	10
Card waste, woolen and worsted	5
Cotton, raw domestic, India, China	11
Cotton merinos	10
Rayon waste	6
Hair, cattle and goat	5
Vegetable fibers, kapok, ramie, jute	1
Miscellaneous and synthetic, silk, viscose and acetate rayon, vinyon, aralac	1

MANUFACTURE

The manufacture of wool felt is characterized by one central productive operation which differentiates its processing from that of all other manufactured materials. This characteristic felting operation is known as hardening. With the exception of hardening, and occasionally finishing, initial and terminal operations follow the general pattern of wool-textile manufacture.

Taking the steps in sequence, the wool is first degreased and, in most instances, depitched and carbonized to remove burrs, seeds, and other foreign matter. Designated proportions of these wools, or wools and other fibers, are then blended according to batch quality formulation. Uniform blending is the most critical initial operation in felt manufacture. It is accomplished by hand-laying the required raw stocks in systematically dispersed layers and hand-feeding representative sections, taken from the top to the bottom of the layed batch, to a conventional type mixing picker. The stock is alternately run through the picker and an air-dispersing blending bin until it is thoroughly opened and uniformly blended. After picking, the blended raw stock is put through a breaker card equipped with a Bramwell or other automatic weighing feed. The breaker card, by means of an Apperly automatic feed system, feeds the roving to a standard-type woolen finishing card to blend and comb the fibers further. From the finishing card, the stock is drawn off in a web supported by slatted aprons and delivered to an endless 42-yd forming apron. Although straight-web felt constructions are frequently used, alternate webs from multiple-card sets are usually crossed to provide transverse as well as longitudinal strength. The forming apron delivers batts ranging from $^1/_4$ to 1 in. in thickness, 36 to 80 in. in width, and 40 yd in length. For most mechanical felt qualities, these batts are then layed up in thicknesses of from 6 in. for roll felts to 3 ft for sheet felts, depending on the required finished felt thickness and density.

Felt hardeners consist of a solid or perforated steam-fed bed-plate, equipped with an oscillating or vibrating top platen of intermittent and adjustable stroke. Steam pressures of from 5 to 10 psi and platen pressures of approximately 70 psf are used. In roll-felt production, top, bottom, and intermediate canvas carrier aprons convey two first-run and two second-run batts through the hardener after preliminary moistening and steaming. First-run batts receive primary hardening and act as a cushion in the final hardening of second-run batts. The interfacial agitation of the batt set up by the vibrating platen, in combination with controlled conditions of moisture, heat, and pressure, causes the fibers to soften, entangle, and reorient themselves in closer locked engagement. Hardening is continued until a lightly felted fabric of sufficient strength to be handled in the succeeding steps of manufacture is formed. As a result of hardening, roll-felt batts (Fig. 2) are reduced in thickness from a maximum of 6 in. to 1 in., and sheet-felt batts from 3 ft to 4 in.

Although the initial felting operation of hardening is exclusive to felt, the final operation, fulling, is common to the entire wool-textile industry. In felt manufacture, however, fulling is a basic processing operation. It is by this means that density, thickness, texture, and yardage are controlled. The compression and interfacial vibration of preliminary hardener felting is of necessity replaced by hammer impact and friction in the fulling operation. According to Hardy, wool fiber, when being milled, travels in the direction of its root end, tends to turn back upon itself, and exerts considerable force in its travel while entangling and interlocking other fibers. As the fibers become more closely interlocked, more work or energy must be applied to overcome interfibrillar frictional resistance. This is the function of the fulling mill.

Felt fulling mills are of several types and include rotary as well as the conventional one-, two-, and four-hammer mills. The latter consist of bin-like receptacles with plano-concave breasts, opposed to which are wooden impact hammers designed with stepped faces. The stroke and cycle of the hammers govern the intensity of fulling while their face design, in conjunction with the breast curvature of the mill, provides the mechanism for turning the felt. Prior to fulling, the hardened material is treated with a fulling agent to lubricate the fiber. In the case of lightly fulled felts, warm water is used. The more dense heavy-duty mechanical and glass-polishing hair felts are most readily fulled by the addition of a 4-deg Twaddell solution of sulphuric acid. Palm-oil soap in the proportion of 1 part to 10 parts of water is considered preferable for soft finish pad and millinery qualities. After treatment with an appropriate fulling agent, the felt is loaded in the mill, folded to a definite pattern to obtain uniform felting for controlled edgewise and lengthwise shrinkage. As the fulling hammers reciprocate, they pound and squeeze the felt in such a way that it is consecutively hammered and turned, providing the pressure and friction necessary for continued felting. Periodically, the felt is removed from the mill, pulled, and refolded to permit inspection and realignment of the pieces, as well as to prevent the formation of wrinkles or the felting together of adjacent surfaces. Fulling may be continued for periods of from 5 min with lightweight felts to 12 hr or more in the case of hard felts. Dimensional shrinkages attained by fulling (Fig. 2) approximate 10 to 20 per cent for pad weights, 40 per cent for back-check weights, and 75 per cent for hard sheet felts.

After fulling, the felt is scoured to remove or neutralize residual soap, dirt, grease, or acid. It is then dyed, hydro-extracted, and tenter-dried under tension in a circulating hot-air drier at a temperature of approximately 140 to 220 F. The felt is then ready for finishing and inspection. Felts for certain purposes are left in the rough as they come from the driers. Others are pressed, sheared on the surface to remove long fiber ends, or, in the case of some of the harder grades, run through a drum sander. From the raw-stock bale to the roll of finished material or cut part felt shipment, the manufacturing process requires 7 to 10 days. It is of interest to note that, although there are only some 10 basic processing operations, some grades

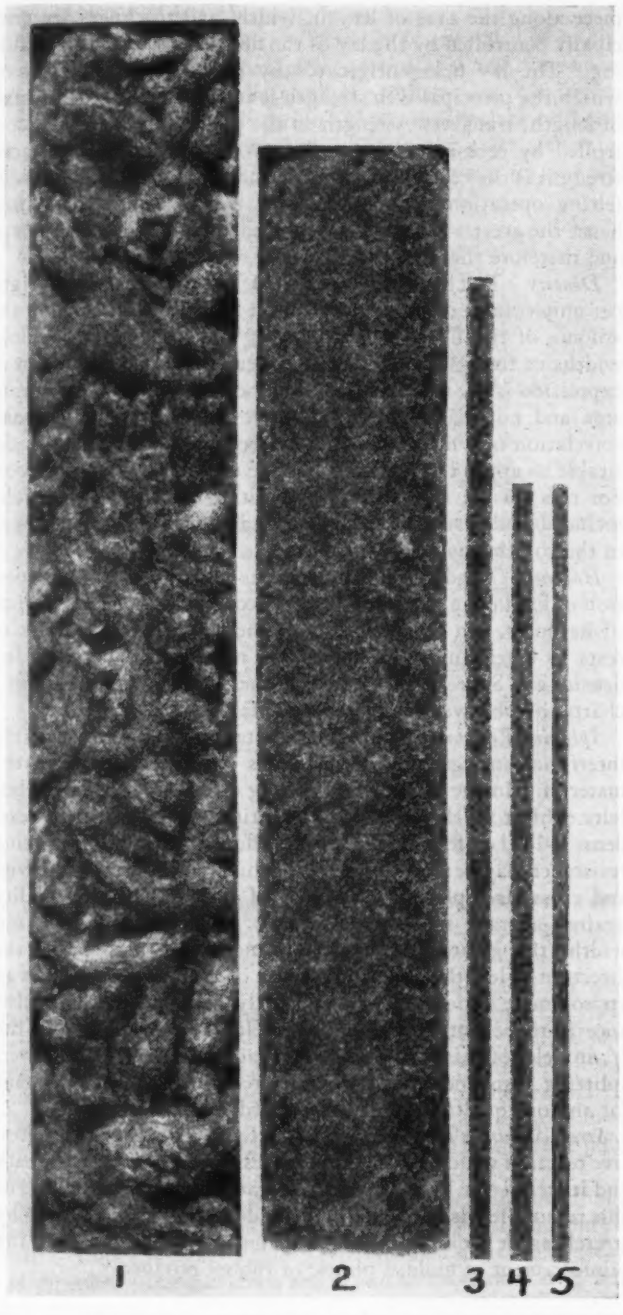


FIG. 2 THICKNESS REDUCTION AND DIMENSIONAL SHRINKAGE ATTAINED IN SUCCESSIVE STAGES OF WOOL-FELT MANUFACTURE, SECTIONAL VIEWS

(1, Initial raw stock; 2, carded raw stock batt; 3, hardened material; 4, fulled material; 5, finished felt.)

of felt are handled no less than 60 times, a fact which in itself emphasizes the degree of craftsmanship entering into the manufacture of wool felt.

MECHANICAL AND INDUSTRIAL USES

Of equal practical importance to the origin and construction of wool felt is the broad range of its mechanical and industrial applications. In these uses it serves a variety of purposes, all more or less governed by considerations of toughness and durability under adverse working conditions. The validity of these qualities is best illustrated by the fact that automobile, farm-implement, and aircraft industries are leading consumers of felt products.

Employed industrially as a friction material, felt provides the traction required to pull strip brass through the cleaning bath in rolling mills and in jacking hides in a tannery. Felt laps and wheels are used extensively in the precision-polishing of high-quality optical and ophthalmic lenses, plate glass, marble, plastics, and tile. Similarly, felt rolls are employed in polishing materials as completely unalike as sheet steel and satin, while wheels and "bobs" of hard sheet felt polish true surfaces on hardened metals as in the finishing of steel dies.

The capillarity of felt adapts it to an entirely different field of mechanical use. Large and small motor-armature shafts are lubricated by means of felt wicks as are journal bearings, spindles, and other remote machine parts. Felt pads absorb, store, and distribute oil, water, ink, and other process fluids in automatic printing equipment, numbering machines, and postage meters. Felt blotters remove excess pigment in several reproductive processes, of which silk-screen printing is but one.

Millions of ball bearings are protected from the ingress of dirt, grit, and moisture, or the leakage of oil and grease lubricants by means of felt seals. Felt pistons for grease guns and self-filling fountain pens, glass pipe gaskets, weather stripping, and drive-shaft-housing seals are typical felt sealing applications.

Because of the versatile blend and distribution of selected fibers in filter felts, they are characterized by slow plugging rates and high retention efficiency. Adapted to both gravity and pressure equipment, they are used for filtering electroplating solutions, solvents, paints, lacquers, and oils. Felt's nonreactive tendencies enable it to be used in filtering photographic emulsions, nutrient broths, and fruit syrups. Capable of sterilization, it has a unique surgical application in intravenous-feeding sets. Widely used in respirators, air conditioning, and industrial dust, fume, and mist filters, it has a tested efficiency in excess of 99 per cent by weight in the removal of 0.5-micron mean diameter lead-fume particles from air.

Wool fibers are natural springs. Vibration isolation, cushioning, and padding are consequently among the natural mechanical functions of wool felt. Felt mountings isolate precision instruments and machine tools from floor or building vibration and, conversely, reduce the transmission of vibrations generated within a machine. As an isolation medium, it is used in agitators, centrifuges, suction pumps, and numerous other mechanical devices. Textile looms, as well as grinders, shears, and punch presses are effectively isolated with felt. Shipments of fine machine parts, radio tubes, and crystals are protected with felt wrappings or pad mountings. Felt bumpers are widely used on the doors of motor vehicles. Message cylinders used in cash-carrier and underground-tube conveyer systems are capped with protective hard-felt bumpers. Vital to the manufacture and continued uniform performance of pianos, felt hammers, backchecks, and dampers demonstrate the extremely long life, impact resistance, and vibration absorption of high-quality wool felts.

As a cushioning material in mechanical processes, felt blankets are used as backing in embossing leather and to bolster the abrasive surfacing material on drum-sanding machines. Utilized for grommets, straps, and spacer pads, felt prevents the squeaks and rattles normally resulting from metallic contact.

Felt is widely used as a surfacing material for the bases of movable equipment, such as telephone and electric-fan bases, providing nonskid and scratch protection for polished surfaces.

Due to its structure, felt is a highly efficient thermal-insulation and sound-absorption material. Applied as a surfacing, it may be used effectively to reduce resonance, adjust reverberation, quiet sound, or reduce heat loss or transmission. This combination of physical properties plus ease of fabrication and low surface density has led to its widespread use in transport and military aircraft soundproofing and thermal insulation.

In summary, as a minimum there are twelve important mechanical functions fulfilled by felt, i.e., filtration, polishing, sealing, wicking, vibration isolation, sound absorption, thermal insulation, shock-absorbing, cushioning, padding, packaging, surfacing, spacing, and frictional.

CHEMICAL AND PHYSICAL PROPERTIES

An understanding of the chemical and physical properties of wool felt is of fundamental importance to its successful selection and application in mechanical design. In order that engineers and designers may properly evaluate and interpret the significance of these properties, a study has been made of six standard felt grades representative of the industry's production and covering the range most commonly specified for mechanical purposes. The results of this study, published on an industry basis for the first time, are reported here in relation to both S.A.E. Standard Felt Specifications and those functional properties important to end-use performance. The first serve to distinguish between and confirm compliance with felt production and procurement specifications; the second, to provide applicational data for study in relation to the selection of felt from the viewpoint of mechanical design. Test procedure followed the methods standardized by the American Society for Testing Materials where applicable; those pertaining to S.A.E. Felt Standards being strictly in accord with A.S.T.M. Methods of Test for Wool Felt, D461. Samples of S.A.E. F-1, F-3, F-5, F-10, F-11, and F-15 felt grades in $^1/_4$ and $^1/_2$-in. thicknesses were cut out of current production at the mills of four different manufacturers and supplied in sufficient quantities to permit parallel testing.

S.A.E. Standard-Quality Compliance Tests. The consolidated average record of test to S.A.E. Specification Standard for these felts is given in Table 2. This compares the test average for each grade with the specified minimum-maximum physical and chemical requirements. Out of 420 separate determinations comprising this series of compliance tests, results of 367, or 87 per cent, were well within the limits prescribed by the S.A.E. Standards. These results notably emphasize the control and high degree of standardization maintained in mechanical felt manufacture and partly account for the growing use of felt as an engineering material.

Applicational Performance Data. Standard specification tests are an absolute measure of felt quality but only a relative measure of performance. They become of practical value to the designing engineer only when they have been related to the required behavior of the material under actual working conditions. It is necessary therefore to review the standard grades as to their performance below destructive-test limits and in relation to functional properties.

Depending on the purposes they are designed to serve, felts differ in density and also in construction. Distinctions between these inherent characteristics largely distinguish the performance of one grade or quality from another.

From the standpoint of construction, relative strengths of the piece along the axes of length, width, and thickness are principally controlled by the lay of the fibers and the degree of fulling. The lay being originated by the carding operation in which the principal web strength is in the direction of the axis of length, transverse strength in the piece is built up and controlled by crossing alternate layers of the webs. Interfacial strength is the result of hardening and fulling. The longer the felting operation is continued, the tighter the interlocking; hence the greater the number of locked fibers in a given volume, and therefore the greater the density.

Density. Felt density, by A.S.T.M. definition, is "the weight per unit volume of the felt under test as distinguished from the volume of the fiber." Since felt is manufactured in various widths of from 30 to 80 in., a convenient commercial form of expression is the weight in pounds or ounces of unit square-yard area and nominal thickness. However, in the analysis and correlation of felt density with related physical data, it is desirable to apply the more basic value of pounds per cubic foot. For this reason, the respective densities for the range of felts included in this study have been added to Table 2 and employed in the correlation of other data.

Hardness. Undergoing study at the present time is the question of finding an expression for the consistency of felt in terms of hardness. In this connection, the results of one series of tests to determine the approximate relationship between felt density and Shore A durometer hardness are of interest. Fig. 3 charts the observed relationship for felts of S.A.E. quality.

Splitting Resistance. Splitting resistance, which measures the interfacial strength of felt, increases with the density of the material. In the present fact-finding tests, the dense F-1 class felts exhibit nearly 8 times the splitting resistance of the least dense F-15 class felts. The general effect of density on splitting resistance may be studied in Fig. 4, which graphs the lengthwise and crosswise splitting resistance of each S.A.E. felt quality against average measured density. As between length and width, the greater splitting resistance appears to be in the direction of length, but a comparison of average values gives an approximate ratio of 1:1. A slightly greater splitting resistance is to be noted for the $^1/_2$-in. felts, as compared with the $^1/_4$-in. felts of this study. For all practical purposes, however, splitting resistance may be considered substantially constant for any one quality and density regardless of thickness.

Stress-Strain in Tension. Felt under tension develops a progressive reaction which accounts for its resistance to increased loads and its relatively high range of elongation before rupture. For this reason, felt is particularly well adapted to form shaping by stretching or molding as in the manufacture of hats or in the reinforcement of molded plastic or rubber products.

TABLE 2 CONSOLIDATED AVERAGE RECORD OF TEST TO STANDARD S.A.E. QUALITY SPECIFICATIONS

SAE QUALITY NUMBER	NOMINAL THICKNESS INCH	THICKNESS Inches		WEIGHT Lb. per Sq. Yd.		DENSITY Lb. per Cu. Ft.		BREAKING STRENGTH Lb. per Sq. In.			SPLITTING RESISTANCE Lb. per 2" Width			WOOL CONTENT Per Cent		SOLUBLES Per Cent						ASH Per Cent	
																CCl_4		H_2O		Combined			
		SAE Spec	Test Data	SAE Spec	Test Data	Tolerance	Test Data	SAE Min	Test Data L	Test Data W	SAE Min	Test Data L	Test Data W	SAE Min	Test Data	SAE Max	Test Data	SAE Max	Test Data	SAE Max	Test Data	SAE Max	Test Data
F-1	.250	.235-.265	.251	3.30-4.20	4.16	19.1-23.8	22.1	500	811	636	33	38	36	95	98	2.5	0.9	2.5	0.9	3.0	1.9	1.0	0.5
	.500	.480-.520	.516	7.60-8.40	7.50	19.5-23.3	19.3	500	848	721	33	42	44	95	98	2.5	0.9	2.5	1.5	3.0	2.3	1.0	0.6
F-3	.250	.235-.265	.260	3.61-4.19	3.91	18.2-23.8	20.0	400	428	438	24	26	24	90	94	2.5	2.1	3.0	1.7	4.5	3.8	1.5	1.2
	.500	.480-.520	.523	7.21-8.39	7.90	18.5-23.3	20.1	400	475	547	24	32	29	90	95	2.5	2.1	3.0	1.2	4.5	3.3	1.5	1.0
F-5	.250	.231-.268	.271	2.91-3.21	3.04	14.5-18.5	15.0	400	640	451	18	18	18	95	98	2.5	1.1	2.5	1.4	3.0	2.4	1.0	0.7
	.500	.470-.530	.521	5.81-6.43	6.01	14.6-18.2	15.4	400	642	567	18	21	19	95	97	2.5	0.6	2.5	1.6	3.0	2.2	1.0	0.6
F-10	.250	.223-.277	.267	2.02-2.24	2.27	9.7-13.4	11.4	225	378	281	8	9	8	95	98	2.5	0.6	2.5	1.1	3.0	1.8	1.0	0.6
	.500	.460-.540	.544	4.04-4.46	4.50	10.0-12.9	11.0	225	399	325	8	8	8	95	98	2.5	0.5	2.5	1.3	3.0	1.8	1.0	1.0
F-11	.250	.223-.277	.253	1.97-2.29	2.24	9.5-13.7	11.8	200	310	229	6	8	9	92	94	3.0	3.1	2.5	1.6	4.5	4.7	2.0	1.0
	.500	.460-.540	.479	3.93-4.57	4.40	9.7-13.3	12.2	200	302	240	6	9	9	92	94	3.0	3.7	2.5	1.2	4.5	4.9	2.0	0.9
F-15	.250	.217-.283	.280	1.97-2.29	2.26	9.3-14.1	10.7	75	172	129	2	6	5	55	86	4.0	1.6	5.0	2.8	9.0	4.4	4.0	1.8
	.500	.460-.550	.528	3.93-4.57	4.45	9.5-13.5	11.2	75	181	131	2	4	4	55	88	4.0	1.7	5.0	2.8	9.0	4.5	4.0	1.9

On the basis of felt construction, it can readily be seen that only a small proportion of the fibers would normally be so disposed as to be stressed under initial tension. When these fibers do yield by even the smallest amount, other interlocked fibers having the same general direction but previously slack will also move and resist being stretched. This effect must either increase the total tensile resistance or compensate for the de-

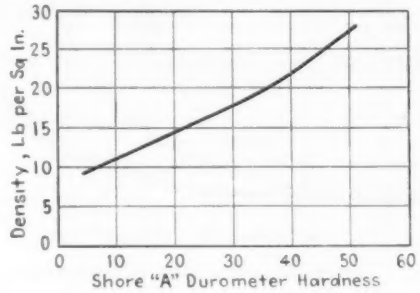


FIG. 3 SHORE "A" DUROMETER HARDNESS - DENSITY RELATIONSHIP OF STANDARD S.A.E. FELT QUALITIES

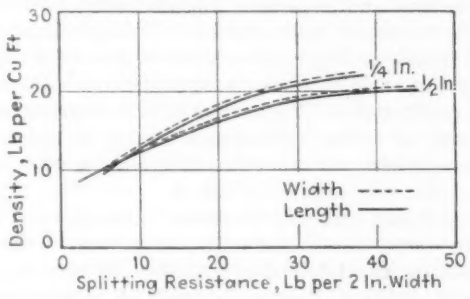


FIG. 4 SPLITTING RESISTANCE - DENSITY RELATIONSHIP FOR STANDARD S.A.E. FELTS IN 1/4 AND 1/2 IN. THICKNESSES

creased resistance of the slipped or broken fibers which were initially stressed. As more load is applied, interlocked fibers lying at an angle to the direction of force will be pulled into line and tensed, adding further elongation, while previously tensed fibers will be drawn together adding further resistance. The net effect is that as the load is increased, an increase in resistance develops and further elongation takes place to the point of rupture.

The influence of felted density on tensile strength and elongation is reflected in the curves, Figs. 5 and 6, averaged from the entire group of tests. Table 3 provides functional design data on the average tensile stress and strain of standard S.A.E. felts before rupture.

From the curves, Figs. 5 and 6, as well as the data in Table 3, the following facts are to be noted:

1 The ultimate elongation of this series of mechanical felts ranges from 0.738 in. per in. at 821 psi for S.A.E. F-1 (20.7 lb per cu ft density) down to 0.463 in. per in. at 156 psi for S.A.E. F-15 (11.0 lb per cu ft density).

2 Transverse strength tends to be slightly less than lengthwise.[2]

3 Ultimate elongation and strain per unit stress tend to be slightly greater widthwise than lengthwise.[2]

4 Each grade of felt has as one of its physical properties a characteristic tension curve or modulus distinct from that of any other grade.

5 Tensile strength and elongation are related in direct proportion to felt density, fiber quality, and the fiber construction of the felt.

[2] Sheet felts, as distinct from the roll felts of this study, are fabricated in squares by orienting alternate layers of webs through an exact 90-deg angle. Sheet felts consequently demonstrate equal strength and elongation in both axes.

Stress-Strain in Compression. When a steadily increasing compressive load is applied to felt by even stages, the thickness of the sample is progressively reduced, conforming to a definite law, according to which the ratio of deformation to load changes throughout the range.

Under light loads compression deviates but little from a constant proportion to increased load and a small increase in load produces a relatively large increase in deformation. As the compressive load is increased, the rate of deformation gradually decreases until, under very heavy loads, compression again approaches a constant proportion to increased load, and a relatively large increase in load produces only a small increase in deformation.

The laws governing the compressive deformation of felt may be considered objectively by regarding felt as a porous structure in which initial deformation is produced by closing down and decreasing the interstitial relationship of the fiber matrix. This stage is followed by one in which the fibers, having been brought into contact, are flattened down until the material approaches a solid state. Further deformation beyond this point requires proportionately greater loading.

Deformation, expressed as a percentage of initial felt thickness, is directly related to density. The consolidated average

TABLE 3 CONSOLIDATED AVERAGE PER CENT ELONGATION OF STANDARD S.A.E. QUALITY FELTS AT STATED LOADS WITHIN NONDESTRUCTIVE LIMITS

S.A.E. Standard	F-1	F-3	F-5	F-10	F-11	F-15
density, lb per cu ft	20.7	20.1	15.2	11.2	12.0	11.0
Load, psi	Per cent elongation					
25	5	6	6	14	12	14
50	8	10	10	24	19	24
100	13	16	16	33	37	35
200	20	27	27	51	53	..
300	28	39	37	..	..	..
400	35	51	47	..	..	..
500	44	..	..	..	..	..
600	51	..	..	..	..	..

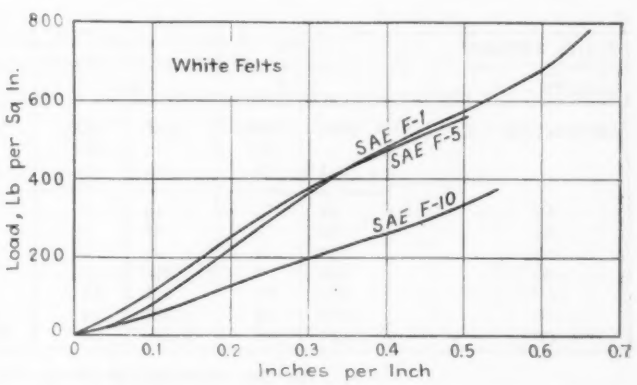


FIG. 5 STRESS-STRAIN IN TENSION: 1/4 IN. TESTED LENGTHWISE

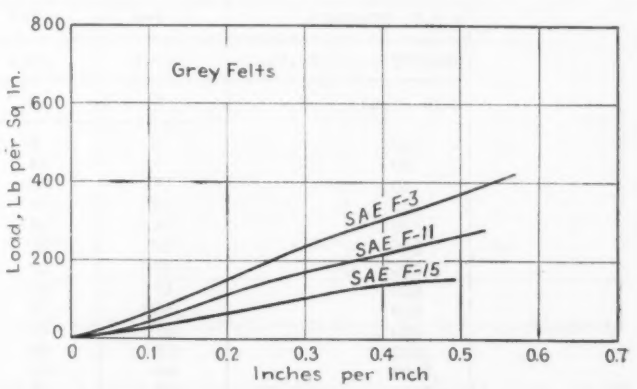


FIG. 6 STRESS-STRAIN IN TENSION: 1/4 IN. TESTED LENGTHWISE

test curves in Fig. 7 chart this relationship graphically and focus attention on the fact that each grade of felt has its own load-compression track or modulus which may be recognized as one of the physical characteristics pertaining to that grade of felt and that grade alone. Table 4 gives the load-deformation and compression-set performance values for each S.A.E. quality.

The method of test for deformation under compression was to apply loads uniformly up to a deformation equal to 80 per cent of the measured original felt thickness. Tests for compression set were performed by loading samples of each felt to 20, 40, 60, and 80 per cent of their original measured thickness for 1 min, releasing the pressure, and measuring the final thickness after 1 min for recovery. Compression set is expressed as the percentage of the difference between original and final thickness to the original thickness.

Within the load limits of the present tests which ran above 20,000 psi, no measurable lateral flow was observed, and it may be concluded that the compressive deformation of felt is entirely normal to the plane of the loaded surface within practical limits of loading. Examination of the test values in Table 4 warrants the following summary observations in relation to the behavior of felt loaded in compression:

1 The higher-density felts demonstrate progressively greater load-bearing capacity than the lower-density felts for any given deformation.

2 The lower-density felts are more highly compressible than the higher-density felts under any given load.

3 The higher-density felts demonstrate less compression set for any given load than the lower-density felts.

4 The lower-density felts demonstrate less compression set for any given deformation than the higher-density felts.

5 S.A.E. F-1, F-5, and F-10 felts, as a result of fiber quality, demonstrate the greatest resiliency for their respective densities.

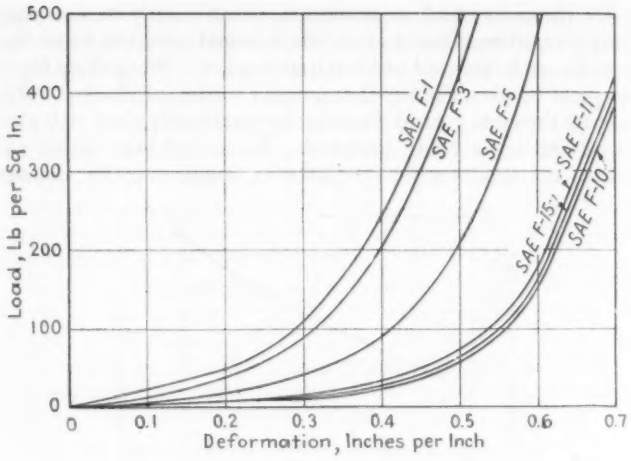


FIG. 7 LOAD—DEFORMATION IN COMPRESSION

From these observations it may be concluded that wool felt is naturally adapted to load-bearing in compression. It does not crumble or flow and exhibits a relatively low compression set even at the maximum loads applied. The high degree of compressibility and resiliency of the lower-density felts under light loads explains their particular adaptability to cushioning and padding applications. Where high load-bearing capacity is a requirement, as in the vibration-mounting of machines, the higher-density felts, with their low compression-set deformation characteristics, are particularly suited.

Effects of Water, Oil, and Chemicals. The effect of distilled water, tap water, chlorinated water, or sea water on the physical characteristics of felt after extended immersion at room temperature, and limited immersion at 212 F, is moderate thickness swell, slight dimensional shrinkage in length and width,

TABLE 4 CONSOLIDATED AVERAGE PER CENT COMPRESSION SET AND DEFORMATION OF STANDARD S.A.E. QUALITY FELTS AT STATED LOADS

S.A.E. STANDARD	F-1		F-3		F-5		F-10		F-11		F-15	
DENSITY - Lb./Cu.Ft.	20.7		20.1		15.2		11.2		12.0		11.0	
DEFORMATION - %	LOAD psi	COMP. SET %	LOAD psi	COMP. SET %	LOAD psi	COMP. SET %	LOAD psi	COMP. SET %	LOAD psi	COMP. SET %	LOAD psi	COMP. SET %
10	21	1	13	1	6	1	4	1	4	1	3	1
20	45	2	35	3	17	2	7	2	7	2	6	2
30	108	4	93	6	41	4	9	3	15	4	10	4
40	246	7	210	9	91	6	24	6	34	6	26	6
50	480	11	421	12	213	10	58	9	72	9	64	10
60	1297	23	1223	24	458	17	151	13	173	13	162	15
80	27890	53	21180	55	7746	53	2382	40	2625	42	3416	42

PER CENT COMPRESSION SET AT LOADS PRODUCING STATED DEFORMATIONS

S.A.E. STANDARD	F-1	F-3	F-5	F-10	F-11	F-15
DENSITY - Lb./Cu.Ft.	20.7	20.1	15.2	11.2	12.0	11.0
LOAD - psi	%	%	%	%	%	%
10	5	8	15	30	25	30
20	9	14	22	39	33	37
40	17	21	30	46	42	45
60	23	25	35	50	47	49
80	26	29	39	54	51	53
100	29	31	41	56	54	55
200	37	39	49	62	61	62
400	47	49	58	71	69	70
600	53	55	62	75	73	74
800	57	58	62	76	74	75
1000	58	59	63	--	--	--
2000	60	61	--	--	--	--
4000	61	62	--	--	--	--

PER CENT COMPRESSION DEFORMATION AT STATED LOADS

and decreased wet breaking strength to the extent of about 25 per cent. Felt redried after extended immersion recovers all of its initial breaking strength and splitting resistance.

Table 5 summarizes the per cent water shrinkage and thickness swell observed on 42 representative S.A.E. felt qualities and densities tested in accordance with A.S.T.M. D461 procedure. The average thickness swell for all qualities approximates 15 per cent and the average shrinkage minus 1 per cent in length and minus 2 per cent in width.

TABLE 5 PER CENT WATER SHRINKAGE THICKNESS SWELL —A.S.T.M. D461 METHOD

Consolidated average record of test for 1/4 and 1/2-inch S.A.E. Standard felt qualities

S.A.E. no.	Per cent shrinkage		Per cent swell
	Length	Width	Thickness
F-1	—0.2	—2.5	15.1
F-3	—1.5	—1.1	17.2
F-5	—0.2	—3.0	14.7
F-10	—0.6	—1.8	13.7
F-11	—1.4	—3.5	14.9
F-15	—2.0	—1.1	17.2

Extended exposure of felt to lubricating oils and organic solvents has no appreciable effect on the dimensional stability or physical properties of wool felt. Strong inorganic acids, such as sulphuric and hydrochloric are noninjurious in concentrations up to 14 deg Be. Nitric acid in 14 deg Be concentration is observed to reduce the breaking strength of wool felt by 30 to 40 per cent after a 5-day immersion. Strong bases or alkalies are naturally injurious.

From the standpoint of aging, felt, unlike many organic materials, may be considered ageless. The natural destructive forces of atmospheric temperature, ozone, and ultraviolet radiation are essentially nonreactive. In this respect, felt is unchanged by increased temperatures up to 212 F. Above 212 F, the wool loses its hygroscopic moisture, becomes harsh to the touch, and the physical properties of breaking strength, elongation, and splitting resistance are adversely affected. Reconditioned to moisture equilibrium at a temperature of 70 F, and a relative humidity of 65 per cent, felts exposed to 250 F for 24 hr demonstrate a decrease in breaking strength and splitting resistance approximating 10 to 15 per cent. Regarding low temperatures, felt is the same at minus 60 F, in the absence of condensate, as at normal room temperatures. At minus 80 F, its properties are only slightly different.

FUNCTIONAL PROPERTIES

In considering the mechanical and industrial uses of wool felt, it has been noted that wool fibers are natural springs and that vibration isolation is consequently among the natural mechanical functions of wool felt. Since the effectiveness of any mounting is related to both the frequency of the vibration to be isolated and the natural frequency of the system or material employed, it is of interest to review the characteristics of felt in this respect.

Table 6, representative of the range of available densities,

TABLE 6 NATURAL-FREQUENCY CHARACTERISTICS AND EFFECTIVE LOADING LIMITS FOR S.A.E. FELTS OF 1 IN. THICKNESS

S.A.E. quality no.	F-2	F-6	F-11
Density, lb per cu ft	21.3	16.3	11.4
Load, psi	cps	cps	cps
2	..	..	30
4	..	..	26
6	..	..	24
8	..	29	..
10	..	27	..
15	..	25	..
20	31	..	..
25	29	..	..
30	27	..	..
35	26	..	..

provides test data on the natural-frequency characteristics of three S.A.E. felt qualities. Values for each quality are reported only for loads within practical limits of effective vibration isolation. Loading beyond the reported limits will result in excessive deformation, increased stiffness of the system, and decreased isolation benefit. Felts of S.A.E. F-11 density are most effective for unit loads of from 1 to 6 psi, S.A.E. F-6 density for loads of from 6 to 12 psi, and S.A.E. F-2 density for loads of from 12 to 35 psi. Of practical interest is the result obtained in reducing vibration transmitted to a concrete floor by an automatic Cotton King dobby loom. Readings taken with a Norton-Young portable seismograph before and after isolation with S.A.E. F-2 felt mountings of 3/4 in. thickness showed a reduction in transmitted vibration of 70 per cent.

(*Continued on page 135*)

TABLE 7 SUMMARY OF SUPPLEMENTARY ENGINEERING DATA RELATED TO S.A.E. FELT QUALITIES

S.A.E. QUALITY NUMBER	ABRASION WEAR			COEFFICIENT OF STATIC FRICTION				OIL ABSORPTION AND CAPILLARY FLOW							THERMAL CONDUCTIVITY[3]
(1)	Felt to Felt 10,000 Rubs/8" Stroke			Felt Against Smooth				S.A.E. No. 20 Oil at 70°F.							K-Factor
	% Decrease in Thickness At Stated Loads in Oz./Sq.In.							24 Hour Absorption	Wicking Rate Inches/Min. Lapsed Time						1" Felt
	8.8	7.0	10.2	Wood	Glass	Metal	Oiled[2] Metal	% Wgt. Increase	5	10	15	30	60	90	120	BTU/Hr./Sq.Ft./°F.
F-1	1.0	2.3	2.1	.37	.26	.22	.18	187	0.5	0.7	0.8	1.1	1.6	2.0	2.2	0.36
F-3	2.1	2.1	3.0	.37	.26	.22	.18	263	0.5	0.7	1.0	1.3	1.7	1.8	2.1	0.35
F-5	3.0	3.0	6.0	.37	.26	.22	.18	318	0.6	0.9	1.0	1.3	1.7	1.9	2.0	0.30
F-10	---	---	---	.37	.26	.22	.18	---	---	---	---	---	---	---	---	----
F-11	---	---	---	.37	.26	.22	.18	364	0.6	0.8	1.1	1.7	2.0	2.2	2.4	0.23
F-15	4.1	7.6	18.5	---	---	---	---	571	0.6	0.9	1.1	1.4	1.6	1.8	1.9	0.24

[1] Sources of Data: Abrasion wear and oil absorption, Booth Felt Company; coefficient of static friction, Felters Company; thermal conductivity, American Felt Company.

[2] S.A.E. No. 80 aviation engine oil.

[3] Thermal and acoustical felts blended with Kapok fiber have tested values of 0.21 K factor and 0.80 sound-absorption coefficient at 512 cps for 1-in. thicknesses of 3.2 lb per sq yd weight.

They Help to Make

ENGINEER OFFICERS

By HARRY R. RICARDO

PRESIDENT OF THE BRITISH INSTITUTION OF MECHANICAL ENGINEERS, HONORARY MEMBER A.S.M.E.

IN 1846, during the period of intense railway development in England, a number of mechanical engineers who were pioneering the development of railways were present at some locomotive trials on the Bristol and Birmingham Railway. A heavy rainstorm caused them to seek shelter in a platelayer's shed, and while in this shelter, they fell to discussing the possibility of forming an Institution where the development and technical difficulties of mechanical engineers could be discussed for their mutual enlightenment.

In January, 1847, a meeting was convened at the Queen's Hotel, Birmingham, with J. E. McConnell, the locomotive engineer of the Bristol and Birmingham Railway in the chair, at which the constitution and rules of the Institution were adopted. George Stephenson, builder of Britain's first passenger railway between Stockton and Darlington, was President, and there were about 107 mechanical engineers as members. J. E. McConnell became one of the first vice-presidents, together with Charles Beyer, who founded the locomotive-building firm of Beyer, Peacock and Company which is still building locomotives, and Joseph Miller.

It is indicative of the obligations which the founders attached to membership that among the rules there is one calling on each member to present at least one communication per annum before the Society tending to advance professional knowledge, or to pay a $4 fine toward the library funds in the case of his noncompliance.

In 1877 the headquarters of the Institution were moved to London, the present Institution building in Storey's Gate, St. James' Park, being built in 1899 and extended in 1912. This contains the administrative offices, two meeting halls, committee rooms, and a library comprising over 30,000 volumes of technical and scientific interest to mechanical engineers.

Admission to the Student and Graduate grades of the Institution is defined by strict examination standards. Admission to the Corporate grades depends on an examination of the practical training and competence in the practice of engineering in addition to the educational requirements.

By 1920 the growth of the practice of mechanical engineering and of the Institution's activities resulted in an extension of the Institution's organization by the formulation of branches in the main geographical divisions of Britain. There are now nine branches in Britain and three overseas. In territories overseas where there are active engineering societies catering for mechanical engineers, the Institution has supported the national engineering society, but has the assistance of local advisory committees or Corresponding Members in the conduct of its own affairs.

At the time of the annual meeting in February, 1944, the total membership of the Institution was 17,404, including 3181 full members, 8608 Associate Members, in Corporate Member classes, and 3048 graduates and 2064 students in the junior classes.

In 1930 King George V conferred a Royal Charter on the Institution, confirming it in its work for the advancement of mechanical engineering, science and practice, and permitting its Corporate Members to use the title "Chartered Mechanical Engineer."

From its earliest days, the Institution attracted to it, and had the benefit of, the services of many of the most distinguished men in British mechanical engineering. Among its earliest presidents were George and Robert Stephenson, Sir William Fairbairn, John Penn, Lord Armstrong, Robert Napier, John Ramsbottom, and Sir William Siemens.

In the early days of the Institution the papers were mainly concerned with new manufactures and methods of fashioning materials, descriptions of new kinds of machines and forms of prime movers. Gradually the subject matter was increased to cover the more theoretical aspects of mechanical-engineering science, the properties of engineering materials and their testing.

All the papers submitted were discussed at Institution meetings, but as the volume of contributions in the form of papers increased, many papers are published which are discussed in writing, although discussion at meetings is still regarded as a most important part of the Institution's work. The importance attached to meetings is evidenced by the fact that they were continued throughout the most trying times of the German bombing attacks on London and in the provinces. During the war, most of the papers presented at meetings have been published but are subject to technical censorship; some of the meetings have been secret under direction from the appropriate Ministry, because of the nature of the matters discussed.

The number of books lent by the Institution library since the start of the war has increased by 73 per cent, and in spite of the difficulties imposed by paper restrictions and the limitations on publication, the number of papers and reports issued has increased by 30 per cent.

In encouraging the advancement of engineering science, the Institution has attached great importance to stimulating research in its fields and, since 1879, has adopted a policy of conducting researches by its own committees, or supporting individual workers in their own researches. In this way, it has been responsible for many notable advances in engineering science.

Apart from its work in advancing the interests of technical education for mechanical engineers by the introduction of its own examinations, the Institution, in 1920, in co-operation with the Board of Education, instituted the National Certificate system of engineering courses and examinations, which has played a profound part in the technical training of mechanical engineers. This system has since been extended to other branches of engineering and science.

It is evidence of the extent to which the educational activities of the Institution have been maintained throughout the war that the number of candidates submitted for these National Certificate examinations has increased from 5454 in the last prewar year of 1939, to a total of 9031 in the last complete year of 1943. This war expansion includes nearly 2400 candidates for an engineering cadet course, founded by the Government with the advice of the Institution, to provide officers for technical corps of the fighting services, thus rendering an in-

(*Continued on page 108*)

Some Recent Developments in ENGINEERING MATERIALS

I Ferrous Metals[1]

By ARCHIBALD BLACK

MANAGER, MECHANICAL ENGINEERING DEPARTMENT, SIMMONDS AEROCESSORIES, INC., NEW YORK, N. Y. MEMBER A.S.M.E.

INTRODUCTION

SINCE the start of the war, we have witnessed the development of critical shortages of various materials—more particularly in the field of metals. As a result there has been a wave of substitutions; steel has had to take the place of aluminum or copper, and wood or one of the synthetics has had to take the place of steel. This situation has been aptly characterized by the cartoonist who not so long ago showed the production man asking the designer "What will we use in place of the plastic that we substituted for the zinc we used in place of copper when we couldn't get steel?" As if this war angle was not sufficient in itself to confuse the materials situation, the last decade or so has seen many of our old materials improved almost beyond recognition and innumerable new ones created at a pace entirely without precedent in our industrial history.

When these war shortages have passed into history, a condition that is very close to attainment already, we may expect to see extensive jockeying for position on the part of the producers of widely different materials. No longer does the designer accept any field as apportioned off to one material or another. Carbon steel, alloy steel, aluminum, magnesium, zinc, copper, nickel, wood, and a long list of synthetics have all become direct competitors in many cases. In some instances, the substitutions have come to stay, for unexpected advantages resulted; in others we will revert to the time-tried ones; in still others it may take years to decide which wins out. Some materials are "naturals" for certain applications just as others are inherently substitutes, and still others are thoroughly satisfactory alternates fully deserving of equal consideration. The product designer in the next few years must needs survey the materials of the past decade with great care. To let his decision be guided by past custom may prove fatal if his competitor is first to appreciate the advantages of some new or improved material. This sketchy review of materials developments of the last ten years has been inspired by appreciation of the necessity for knowing at least something about these recent changes in the kaleidoscopic materials picture.

When this paper was planned, the scope of the task was fully realized, and it was decided that it would be impracticable to cover in complete detail every one of the important developments in engineering materials that was either introduced or gained prominence in the past 10 years. Hence the author planned his paper as a "digest" for the benefit of those engineers whose work had not brought them into contact with all of the items covered here. Because of the vast area that had to be covered, it is almost certain that he has failed to include a few developments despite effort to guard against serious omissions. Owing to censorship restrictions, he has also been forced to omit a few items that might otherwise have been included. With a few exceptions, the draft of each portion of this paper has been submitted to and corrected by engineers in the field covered by that portion; in the final revision these comments have all been taken into consideration.

[1] The Bibliography published with this section which is the first of four installments which will appear in subsequent issues, applies to this section only. Each section has its own Bibliography.

This section was contributed by the Metals Engineering Division and presented at the Annual Meeting, New York, N. Y., Nov. 27–Dec. 1, 1944, of The American Society of Mechanical Engineers.

TYPES OF FERROUS METALS CONSIDERED

NATIONAL EMERGENCY STEELS

The development of the NE series of steels resulted from the critical shortages of nickel and chromium which inspired a request of the Office of Production Management of the United States, in September, 1941, that efforts be made to find substitutes for chromium and nickel in steels. A committee of metallurgists of the American Iron and Steel Institute, the Society of Automotive Engineers, and various interested steel manufacturers and large users held several conferences as a result of which the National Emergency series came into existence. These steels began with the 8000 series which contained limited amounts of nickel and chromium (0.40 to 0.60 each) and of molybdenum (ranging from 0.10 to 0.60, depending upon steel). They were followed later by other series. This development necessitated extensive investigations of the physical properties of the new compositions, the completion of which was enormously facilitated by general use of the Jominy "end-quench" method, in which a cylinder of steel is heated and quenched by a spray of water impinging on one end. Readings of hardness taken at measured distances from the quenched end provide from the single test a measure of the hardenability of the steel with varying quenches. The net result of the far-reaching departure in steel manufacture was to create a completely new series of low-chromium-nickel-molybdenum steels having properties comparable with the former groups, showing 10 to 18 per cent elongation, when heat-treated to 125,000 psi and, in most cases, capable of heat-treating to show 200,000 psi or over. For additional details, references on the physical properties are being appended.

The NE steels have now become so generally accepted that designers and steel producers are trying to evaluate the extent to which they will remain in use after the end of the war. About one third of the total alloy-steel output of 1943 was NE types. Already users have become accustomed to them and habit is not easily changed. Indications are that many of the NE steels will remain in use long after the end of the war since they have shown the way to produce a high-strength alloy steel with more efficient use of the more expensive alloying elements. Thus they will have in their favor the important advantage of some saving in cost in the days when price comes back into its own as a determining factor in the choice of a material. Among others, the editorial staff of *Metals & Alloys* made a careful investigation of the opinions of metallurgists and materials engineers in the spring of 1944. The concensus of opinion was as follows: (*a*) The NE steels are here to stay but they will not represent as high a proportion after the war; (*b*) the 8600 and 8700 series are likely to

remain the most popular of the entire group; (*c*) the 8900 and 9600 series may disappear; and (*d*) the older alloy steels will regain some but not all of the ground lost during the war.

LOW-COST ALLOY STEELS

About 10 years ago, some of the producers of steel sheet and strip introduced groups of low-alloy moderate-cost steels which have been marketed under various trade names and some of which combined good atmospheric-corrosion-resisting properties. The steels for which no special claim for corrosion resistance was made developed up to 90,000 psi ultimate tensile strength. These steels contained small to moderate amounts of carbon, moderate amounts of manganese, copper, chromium, nickel, and small fractional percentages of molybdenum and zirconium. The corrosion-resisting series developed up to 70,000 psi ultimate tensile strength, combined with resistance to atmospheric corrosion that ranged from 4 to 6 times that of the ordinary copper-bearing steels. This series had a low carbon content with moderate amounts of manganese, silicon, copper, and chromium; in some cases phosphorus was also included. All of these steels received fairly wide acceptance prior to the war and were applied to such uses as railroad cars, automotive vehicles, and other cases where high strength and moderate cost or high strength, corrosion resistance, and moderate cost were desired. In this connection it might be noted that a government-sponsored project is now under way which aims to utilize chrome-nickel-molybdenum scrap in the production of low-alloy moderate-cost steels.

ISOTHERMAL TRANSFORMATION OF STEEL

For many years the iron-carbon diagrams in general use have ignored the time factor in steel transformations. The assumption was made that (for all practical purposes) the change took place as soon as each portion of the steel passed through the critical temperature. Metallurgists of the U. S. Steel Corporation, while studying the hardening of quenched steel in 1928, noted that the time periods in heat-treatment had a most important influence on the character of the steel. This had also been noted by earlier experimenters, but the effect had never been thoroughly studied, hence it was decided to include a complete investigation within the scope of the experiments then being made. From the results, E. S. Davenport and E. C. Bain of the Steel Corporation prepared the first isothermal transformation curves for steel, presenting these in their paper before the American Institute of Mining and Metallurgical Engineers in September of 1930. From their characteristic form these curves have become known as the "S-curve" of a steel.

Out of the investigation there came a number of far-reaching results. The first was the discovery of a hitherto unsuspected structure in iron-carbon alloys; this structure forms at temperatures intermediate between those at which pearlite and martensite form and has been called "bainite" after its discoverer. Bainite may be described as a product of the decomposition of austenite having some resemblance to slightly tempered martensite, but usually distinguishable from it by appearance under metallographic examination. It is formed at temperatures usually between 350 and 900 F (depending upon composition of the steel) and is characterized by its ability to impart greater toughness to steel at high hardness, as compared to tempered martensite at the same hardness. Indeed, it has been described as imparting to carbon steels much of the toughness characteristic of the alloy steels.

INTERRUPTED QUENCHES

From this discovery came the introduction of the "interrupted quench." By modification of quenching methods, it has become possible to avoid entirely the martensitic condition and obtain a steel that combines hardness and toughness. The process named "austempering" (covered by U. S. Patent 1,924,099) represents the application of this discovery. This process interrupts the initial quench and holds the steel at an intermediate temperature until transformation takes place. A final quench is optional but not essential to the success of the process. The reheat and requench for "tempering" or "drawing" is entirely eliminated. The results are rather surprising. As will be noted from the accompanying Table 1, full hardness and full tensile strength are attained yet there is a very striking gain in ductility, as evidenced in impact and bend tests. It is probably no exaggeration to say that the interrupted quench represents the first really radical departure from the time-honored "blacksmith method" of heating steel, holding the piece in the hand tongs until the color "looked right," dunking it in a tub of dirty water, and then using a drawing reheat and requench to undo some of the damge.

TABLE 1 EFFECT OF VARYING HEAT-TREATMENT OF 0.180-IN. ROUND BARS OF STEEL, C-0.78, Mn-0.58, Si-0.146, P-0.042, S-0.040

Property measured	Quench and temper method	Interrupted quench (Austempered)	Change
Rockwell C hardness.	49.8	50.1	Plus 0.3
Ultimate tensile, psi.	259,000	259,300	Plus 300
Elongation, per cent.	3.75	5.0	Plus 1.25
Reduction of area, per cent.....	26.1	46.4	Plus 20.3
Impact, ft-lb (unnotched).....	14.0	36.6	Plus 21.6
Bending (free).....	Ruptured at 45 deg	Passed 150 deg without rupture	Plus more than 105 deg

As a further development from the foregoing came still another type of interrupted quench which has been named "martempering." This method differs from austempering in the respect that it is definitely aimed at the production of a martensitic structure which austempering aims to avoid. Its purpose is that of avoiding the internal stresses that are created in steel by the usual complete quench. Martempering covers any quenching procedure which is based upon a recognition of the theory that martensite forms over a range of temperature from the "Ms" point to the quenching-bath temperature, provided the critical cooling rate has been exceeded. It usually consists of a direct quench into a molten bath held at a temperature corresponding to that at which very little martensite has, as yet, formed; holding in the bath until the temperature has equalized throughout the piece, and then permitting the cooling in air. It may consist of an accurately timed quench in an intensive medium, transfer to a bath maintained about 400 F, and then following the cycle just mentioned or allowing the cooling in air after the timed intensive quench. This process was originated by B. F. Shephard, chief metallurgist of Ingersoll-Rand Company, Phillipsburg, N. J.

COLD TREATMENT OF STEEL

For many years, one of the troublesome problems in the manufacture of precision gages has been the fact that tool steels do not attain a condition of stability immediately after hardening. Experience showed that a precision block, for example, goes through a stage of growth and distortion extending, normally, over a period of a few years. The seriousness of this is best illustrated by pointing out that, for a precision gage block, the growth may attain as much as 10 or 20 times the permissible tolerance. Metallurgical explanation seems to lie in failure to complete entirely the transformation from austenite to martensite in the initial quenching operations. The condition became known to gage makers many years ago and resulted in the adoption of an "aging" practice which called for exposing the semifinished gages to the slow cycle of normal outdoor temperatures over a few years. Various investigations developed the fact that the transformation of

high-speed steel becomes more nearly complete if the steel is brought down to a low temperature for a period of a few hours immediately after quenching. Increased hardness, strength, and ductility, as well as greater stability, are thus attained. The application of this discovery, made possible by the development of low-temperature refrigeration equipment, revolutionized the methods of hardening and aging tool steel. Considerable research is still going on, and some disagreement still continues among experimenters, as to time and temperatures. Only very limited publications have been made to date on results attained; latest available information shows that most rapid results in stabilization are attained not by low temperature alone but by cycling the steel between high and low temperatures several times.

Steels have been completely stabilized by this method in periods asshort as48 hours,as against the several years formerly required for natural outdoor aging. While, as noted, the findings of experimenters have differed as to times and temperatures, most of the results indicate that the steel should be brought down to some temperature below —100 F, immediately after quenching and cycled between that and some temperature above 300 F a certain number of times, ranging up to about 6 complete cycles. Most experimenters seem to agree that the temperatures at the extremes of the cycling range vary with different steels; some claim that temperatures just under —50 F are sufficiently low if the temperatures are cycled a sufficient number of times.

In addition to providing the vitally important gain in stability, it was also found that the cold treatment has a tendency to produce increased hardness and improved ductility at the same time. It is interesting to note here that, in 1932, Luerssen and Greene discovered that certain stainless steels on the border line between austenitic and martensitic can be hardened appreciably by cooling to below room temperature. A stainless steel containing 17.5 per cent chromium and 5 per cent nickel was hardened by quenching in dry ice.

STEEL HARDENABILITY CALCULATED FROM COMPOSITION

Within recent years, it has been made possible to calculate, with a good degree of accuracy, the physical properties attainable with a steel where the chemical composition and grain size are known. This rather startling advance in metallurgy was made possible mainly by the excellent work of M. A. Grossmann of the Carnegie-Illinois Steel Corporation. Dr. Grossmann's first publication of the results of his studies was made in his paper on this subject which was presented before the February, 1942, meeting of the American Institute of Mining and Metallurgical Engineers.

By means of curves and tables, the hardenability (or depth of hardening) of a steel can be calculated quite reasonably for a first approximation. Starting with the chemical composition, multiplying factors are applied to the amounts of the various elements. The procedure is as follows: The steel is first considered as having a "base hardenability" due to its carbon content alone; from the carbon content and grain size the "ideal bar diameter" is read from the chart in the upper left of Fig. 1. This diameter represents the size of bar that will harden to a 50 per cent martensitic structure at the center when the surface is instantly cooled to 70 F. (This, it should be noted, assumes the impossible condition of a perfect quench, but the hypothetical conditions are still sufficient to permit application of the method with reasonable accuracy.) The diagram in the center left of Fig. 1 gives curves for reading the multiplying factors for the various other elements present in the steel. Application of these multipliers gives the diameter of a bar (of the composition under consideration) that will harden to the same extent (50 per cent martensitic) at its center. By use of the figures at the left and top scales of the chart on the lower left of Fig. 1, this diameter is then used to obtain the "Jominy equivalent," or the distance from the end of the Jominy end-quenched specimen at which the hardness will equal that of the center of the hypothetical bar. The actual hardness is read from the lower curve by aid of the lower and right scales in the same chart.

This author has had no personal experience in the application of Grossmann's method but is informed that the results attained are sufficiently good to provide a first estimate for probable hardenability. The method is particularly useful for plain-carbon and low-alloy construction steels. The highest-alloy construction steels have not yet been satisfactorily evaluated. Grossmann's method represents a valuable addition to steel metallurgy, since it permits approximation of the strength of a steel before that steel is made.

HIGH-STRENGTH CAST IRONS AND CAST STEELS

So much improvement has been made in the tensile strength of cast iron and cast steel within the last decade or so that these materials have to be reviewed in the light of current showings rather than some old textbook figures. By 1941, the A.S.T.M. specifications for cast iron had been increased from three to eight classes, and the maximum tensile strength from 20,000 to 60,000 psi. Even this is not the top, for cast irons developing up to 80,000 psi are now made for special purposes. Improvement has resulted mainly from improved melting practices, the addition of alloys, and heat-treatment. Somewhat similar progress has been made in the melting technique, control of inclusions, and deoxidation of cast steels. For these, the A.S.T.M. specifications now range up to 150,000 psi and yield of over 125,000 psi with minimum elongation of 10 per cent. In other steels of the "chrome-moly" type, the tensile strength runs to 205,000 psi with 5 per cent elongation. Here, the improvement is due mainly to the addition of alloying elements and to heat-treatments.

LEADED STEELS

Credit for a radical departure in steelmaking belongs to the Inland Steel Company, which firm sponsored and directed the research carried out by the staff of the Battelle Memorial Institute, to determine the effect of lead in steel. This resulted in the marketing of "Ledloy," a free-machining steel, containing about 0.25 per cent of lead, which may be in addition to, or in place of, the usual "high sulphur" content. The Battelle investigations showed that the machinability of steel is increased when as little as 0.10 per cent of lead is present, and that it improves until about 0.50 per cent is present. The same general improvement is shown by low-sulphur and high-sulphur steels.

Prior to the development of leaded steel, it had been commonly believed that lead was insoluble in liquid steel and that any lead present would be in the form of segregated pools in the metal. This, however, is not borne out by the examination of the structure of the leaded steel now produced, and the presence of lead is generally determined only by chemical analysis. The outstanding feature of leaded steels is the lack of embrittlement that is common to the "high-sulphur" method of rendering steel more readily machinable.

Study of a tabulation of Charpy impact tests on leaded and unleaded steel shows that the proportions used (0.25 per cent and less of Pb) have no embrittlement effect whatsoever. Investigation of the effect upon tensile strength, yield point, and endurance limit brought a rather similar result, the leaded steel showing no appreciable loss in strength or in Brinell hardness numbers. This was found to be true even with medium- and higher-carbon steels. The same was found to be true for hardenability, no appreciable change being evident.

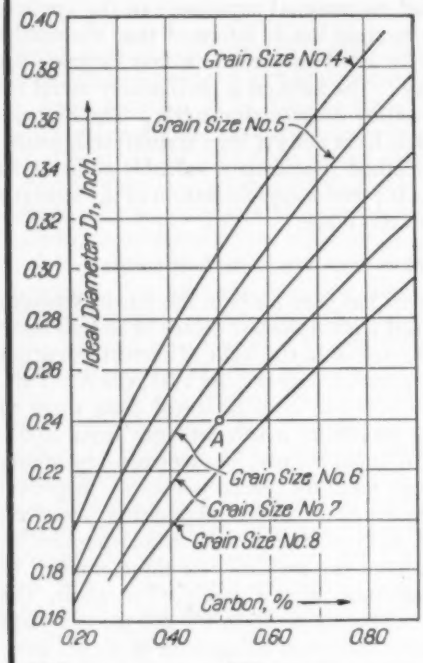
GRAPHITIC STEELS

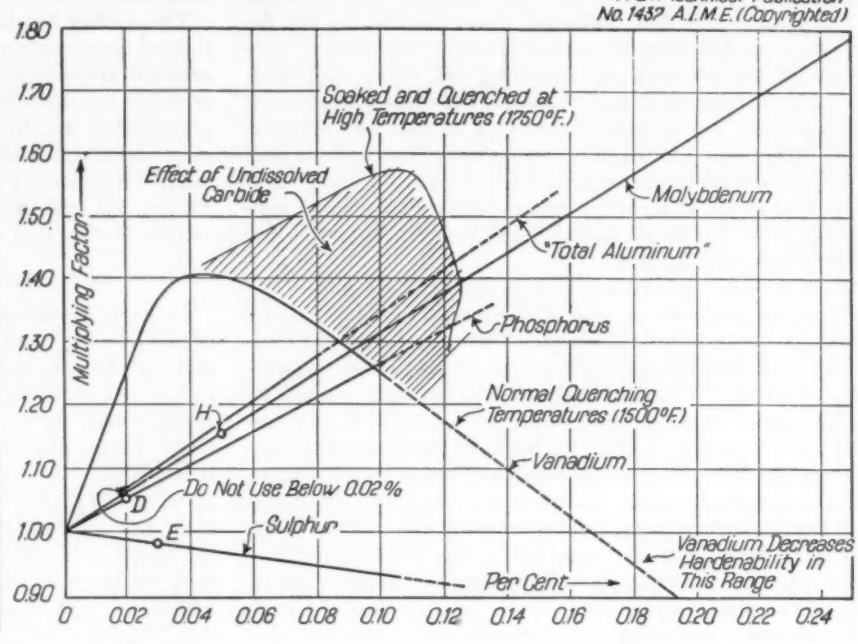
As a result of an extensive development program, conducted by the Timken Roller Bearing Company, there has been made available since 1937, a group of steels which contain free graph-

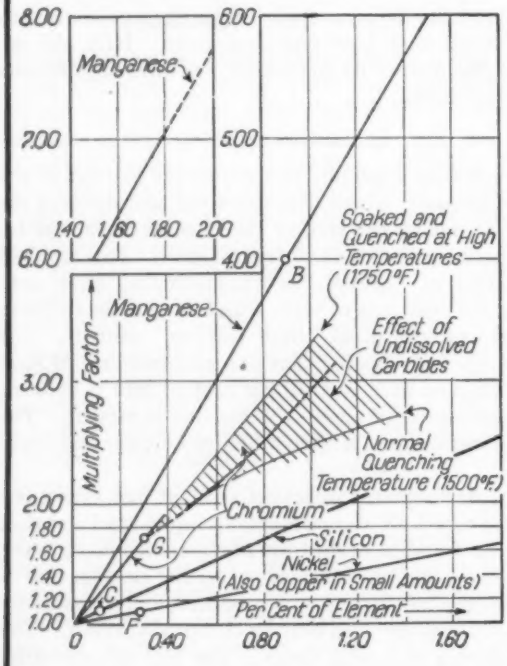
Hardenability Calculated From Composition

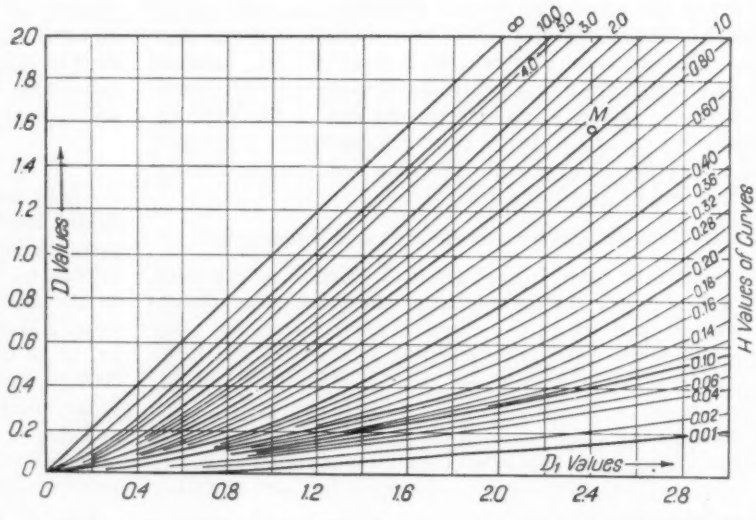
By Marcus A. Grossmann

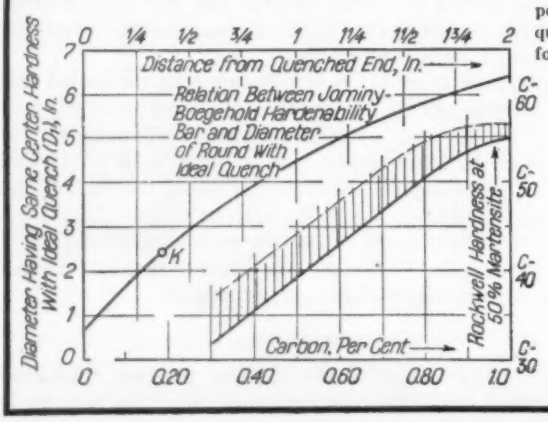
From Technical Publication No. 1437 A.I.M.E. (Copyrighted)










Distance from Quenched End, In.
Relation Between Jominy-Boegehold Hardenability Bar and Diameter of Round With Ideal Quench
Diameter Having Same Center Hardness With Ideal Quench (D_1), In.
Rockwell Hardness at 50% Martensite
Carbon, Per Cent →
K

Example: To compute hardenability of a commercial steel of the analysis shown:

Item	Amount	Factor	Point
Grain size	7	0.24	*A*
Carbon content	0.50		
Manganese	0.90	4.00	*B*
Silicon	0.10	1.10	*C*
Phosphorus	0.020	1.05	*D*
Sulphur	0.029	0.98	*E*
Nickel	0.28	1.10	*F*
Chromium	0.30	1.70	*G*
Molybdenum	0.05	1.16	*H*
Copper	0.05	1.02	★

★Estimated on the line for nickel.

Ideal hardenability of given steel = D_1 = 0.24×4×1.1×1.05×0.98×1.1×1.7×1.16×1.02 = 2.40. Such figures for D_1 will accurately compare one steel with another.

Jominy equivalent of the given steel at point *K*, that is, hardness of center of ideally quenched 2.40-in. bar, is the same as that found 5/8-in. from end of end-quenched specimen.

Actual hardness at center, taken from lowest curve, is about C-45 for 0.50 carbon, low alloy steel.

Quenching power H of commercial baths may be determined by methods shown in the data sheet, Metal Progress, Oct. 1941, page 520, or estimated from the table at right, below.

Example: Water quench, mildly agitated; H = 1.05; Steel D_1 = 2.40. Actual critical diameter D (from point *M* above D_1 = 2.40) is $1\frac{5}{16}$ in., size of bar of given steel that will harden in given quench to half martensitic structure at center; hardness C-45.

Circulation or Agitation	Value of H for		
	Oil	Water	Brine
None	0.25 to 0.30	0.9 to 1.0	2
Mild	0.30 to 0.35	1.0 to 1.1	2 to 2.2
Moderate	0.35 to 0.40	1.2 to 1.3	....
Good	0.4 to 0.5	1.4 to 1.5	....
Strong	0.5 to 0.8	1.6 to 2.0	....
Violent	0.8 to 1.1	4	5

FIG. 1 HARDENABILITY CALCULATED FROM COMPOSITION
(From Technical Publication No. 1437 A.I.M.E.)

ite included in the structure. These steels thus combine certain properties of cast iron (such as easy machining, nonscuffing or scoring, and resistance to wear), with the uniform structures, the ready response to heat-treatment, and good physical properties of tool steel. The formation of the free graphite in the structure is controlled by specially selected compositions with an average carbon content of 1.50 per cent and which also contain molybdenum, tungsten, aluminum, nickel, chromium, etc., in varying contents depending upon the application.

There are now available five grades of these steels each of which has properties that fit it for certain types of applications. The classification includes a deep-water-hardening grade, a shallow-water-hardening grade, an oil-quenched nondeforming grade, a high-wear-resistant water-hardening grade, and an air-hardening grade.

These grades are now being used for cold-working dies, tools, punches, cams, taps, mandrils, machine parts, etc. They are produced in a variety of shapes such as bars, sheet, strip, forgings, seamless tubing, etc., and, while they cannot be cold-worked, all difficulty in hot-working has been overcome.

BORON STEEL

The utilization of boron in steel has been under investigation for nearly 40 years. Initial studies, however, were concerned with percentages of this element which, although small, produced a steel which was found to be unworkable due to hot shortness. Eventually these investigations were abandoned. In more recent years, the work was revived but on a different basis, the amount of boron being drastically reduced to very tiny fractional percentages. The results were most gratifying for it now developed that as little as 0.0006 per cent of boron produced a distinct effect in increasing the hardenability of steel. The most advantageous proportions were found to be around 0.002 per cent. If this is much increased, hot shortness begins to appear and, if further increased, the metal becomes so hot short that it is unworkable. It appears that boron acts very much like some of the other elements (such as manganese, chromium, nickel, molybdenum, etc.) which are used in the "alloy" steels to increase "hardenability." (Perhaps it might be well to point out here that we are speaking of "hardenability" not hardness. We are thus concerned only with the depth to which a steel is capable of hardening when quenched.)

The chief difference between boron and other alloying elements seems to be in its greater effect, which forces the steelmaker to use exceptionally small proportions and these, in turn, require exceptional care to insure their equal distribution throughout the metal. Because of such conditions, its introduction in the form of a "master alloy" is even more essential with boron than with some of the better known alloying elements. Several metallurgical firms are marketing boron-content master alloys for steelmakers and some mills are now producing boron-content steel.

ZIRCONIUM-BEARING AND COLUMBIUM-BEARING IRON AND STEEL

Zirconium in fractional percentages has recently been introduced into some of the high-tensile alloy steels for the purpose of improving impact resistance, ductility, and cold-forming characteristics. Zirconium is one of the strongest deoxidizers available and is an effective grain refiner. It also combines readily with sulphur and nitrogen, rendering these impurities harmless to the steel. Heat-resistant cast irons containing 1.5 to 2.0 per cent chromium are being brought within the machinability range by the addition to the ladle of silicon-manganese-zirconium master alloys, which have the effect of decreasing the amount of combined carbon in the finished metal, thus making it relatively free-cutting.

Small percentages of columbium are now being used quite generally in steels of the austenitic chromium-nickel type for the purpose of preventing susceptibility to intergranular corrosion to which this type of steel is subject when exposed to corrosive media after having been held in the temperature range of 800 to 1500 F. As some part of the parent metal in the weld zone is always heated within the "sensitizing" temperature range during welding operations, it is often necessary in the case of ordinary austenitic steel to restore its original resistance to intergranular corrosion by a heat-treatment which it is frequently difficult or impossible to perform. The use of columbium-bearing austenitic chromium-nickel steel plate and welding rod removes the necessity for such heat-treatment subsequent to welding and greatly simplifies the fabrication of welded stainless-steel equipment. In the so-called "straight-chromium" steels, columbium tends to prevent air-hardening and to improve creep strength, weldability, and corrosion resistance.

NITROGEN AS AN ALLOYING ELEMENT IN STEELS

The element nitrogen, which steelmakers have, for years, considered highly undesirable, has recently proved itself a valuable addition to certain steels. The initial use of nitrogen, of course, came with the introduction of the nitriding process of casehardening, but this seems to have had no direct connection with the subsequent development of nitrogen as an alloying element. As a general rule, all steel contains a very small, almost infinitesimal, amount of nitrogen. This is picked up from the atmosphere in the smelting process, but the amount is too small to have any noticeable effect on the properties of the metal. Where present in fractional percentages, nitrogen has been found to have a most important effect on practically all chromium steels. The effect is most pronounced in the case of those containing over 11 per cent chromium. Metallurgists believe that the nitrogen combines to form either chromium nitrides or iron chromium nitrides. When the ratio of nitrogen to chromium is below about 1 to 100, the nitrides seem to remain in solution in the steel at all temperatures. In the martensitic (or hardenable) type of stainless steels, the effect of nitrogen is like that of carbon in that it increases the hardness and tensile strength but, unlike carbon, it has little or no effect upon toughness or resistance to corrosion. The same is approximately true for the ferritic, nonhardenable 16 to 18 per cent chromium steels. In the case of the 20 to 30 per cent high-chromium steels, the effects of nitrogen are extremely marked. Here, the effect is to increase both the ductility and the strength. In the case of the 18 and 8 chromium-nickel austenitic, the addition of nitrogen has the effect of improving the tensile strength materially without impairing either the ductility or the corrosion resistance.

NITRIDE CASEHARDENING OF STAINLESS STEELS

Nitriding of stainless steels of the chromium-nickel austenitic type and the straight chromium type is now being done by several firms. The nitriding of austenitic stainless steel was first accomplished some years ago in England, the passive oxide surface film being originally removed by pickling in hydrochloric acid or phosphoric acid, or by the use of a strong alkali bath, such as caustic soda. In recent years, a patented process has been used by several firms in this country which utilizes hydrogen from dissociated ammonia to reduce the oxide film prior to nitriding the surface with ammonia gas. The process necessitates the use of a muffle furnace from which all air is excluded from the start, until the temperature has been returned again to below the point at which surface discoloration occurs. The case is very shallow, in general, not exceeding about 0.005 in. in thickness. The hardness ranges up to more than 1000 Vickers. The hardness of this surface layer is due to the formation of nitrides by chemical combination of the nitrogen from the ammonia with the iron, chromium, and other elements in the steel. This results in substantial improvement in hardness and in wear resistance but at some sacrifice of resistance to certain types of corrosive attack, since a

large portion of the corrosion resistance of austenitic stainless steel is due to the superficial film of oxides on its surface.

SILICON IMPREGNATION OF STEEL

A method of impregnating the surface of iron and steel with silicon is now in commercial use under the trade name of "Ihrigizing," being so called after its inventor. Its advantages are that of imparting to the steel resistance to corrosion, heat, and wear. The materials capable of treatment include all types of wrought or cast steel with low carbon and low sulphur content. The medium-carbon steels can be impregnated also but require considerably greater time; high-sulphur steels of the "free-machining" type and gray cast irons, because of their sulphur content, are not suitable for impregnation, as the corrosion resistance is unsatisfactory. As a general rule, alloy steels are not as well suited to the process as straight carbon steels.

In application, the metal is cleaned and subjected to the action of silicon carbide and chlorine at temperatures of 1700 to 1850 F. However, ferrosilicon or mixtures of ferrosilicon and silicon carbide may be used for the purpose instead. Ordinary carburizing equipment is used with slight modifications, and the chlorine is added when the parts are up to heat. The exact process of the reaction is not known, but the result is to impregnate the surface of the metal with silicon, the depth ranging from 0.005 to 0.1 in., according to the time of exposure. The carbon in the silicon-impregnated portion is pushed back into the body of the metal, becoming concentrated underneath the silicon case. Analyses show that the silicon content at the surface runs as high as 14 per cent. Unlike the carbon in carburized steel, however, the silicon content is almost constant through the depth of the case. The effect of the treatment is to make the metal exceptionally high in corrosion resistance, as well as in heat resistance and wear resistance. A cut section of treated steel has been boiled in dilute nitric acid until the entire core was eaten away and only the siliconized case left. The surfaces of treated parts show a Rockwell hardness of B-80-85.

NEW MAGNETIC ALLOYS

Commercially, the most important among the developments in magnetic materials in the past decade is the "Alnico" series of alloys, developed by the General Electric Company. These represented a distinct departure from the permanent-magnet compositions previously used, being based upon the combination of iron, nickel, and aluminum; later, in some cases, cobalt, or cobalt and copper were also added. The first of the group was originally announced as "Alnic" in 1933 and is now called "Alnico III." As permanent magnets, these alloys furnish more magnetic energy per unit cost or unit of volume than any other materials that are commercially available. It happens that they do not possess the highest magnetic properties yet developed, as there are some considerably more expensive alloys which are capable of exceeding the performance of the Alnico I to IV series. Most notable among these others are some platinum-cobalt alloys containing over 76 per cent of platinum, but the excessive cost of the platinum content precludes their use for most commercial applications.

With the exception of Alnico V, the nickel-aluminum or "Alnico" group of magnet alloys must be cast or sintered as they are all Rockwell to C 50 or over and are thus too hard to machine; similarly, they are also too brittle to form by working and are finished by wet-grinding. The sintered Alnico has fine grain and even flux distribution, while cast Alnico, due to larger grain structure, is more brittle than the sintered material. The Alnicos usually require heat-treatment to develop their highest magnetic properties. They are distinctly more stable than any permanent-magnet alloys previously used and can be subjected to considerable external magnetic force before their permanent magnetism is impaired.

Alnicos I and II, the compositions most generally used today, contain, respectively, 20 per cent nickel, 12 per cent aluminum, and 5 per cent cobalt, the remainder being iron, and 17 per cent nickel, 10 per cent aluminum, $12\frac{1}{2}$ per cent cobalt, and 6 per cent copper, the remainder being iron. These alloys have been in general use for permanent magnets for microphones, instruments, clutches, phonograph motors, magnetos, and many other applications for several years.

Alnico V, newest and strongest of the series, is widely used where weight and size are important factors. This alloy contains 14 per cent nickel, 8 per cent aluminum, 24 per cent cobalt, 3 per cent copper, and remainder of iron and has an external-energy value 3 times that of Alnico II. It has strong directional properties which are developed by final heat-treatment in a magnetic field.

Magnets possessing very high coercive force, and light weight are now being made by sintering together powders of cobalt oxide and iron oxide. The specific gravity of the sintered material is less than one half that of solid magnet alloys and this is being utilized to advantage in some aircraft applications where weight is of special consequence.

An alloy of silver, manganese, and aluminum, named "Silmanal," also has a very high coercive force, but very low residual force. Unlike many other permanent-magnet alloys, this material can be rolled, swaged, drawn into wire, and readily machined. Two other ductile permanent-magnet alloys are produced by the General Electric Company. One is an alloy of copper, nickel, and iron; the other is an alloy of copper, nickel, and cobalt. Both are ductile, malleable, machinable, and precipitation-hardening, and can be worked or machined even after hardening. Both alloys are moderately corrosion-resistant.

In addition to the development of entirely new magnetic alloys, research on some of the slightly earlier ones brought to light certain characteristics which had not been observed before. Investigations of cold-working and heat-treating disclosed that some alloys showed substantial improvement in their magnetic characteristics after being subjected to a strong magnetic field while at a high temperature.

NICKEL-IRON-TITANIUM ALLOYS

A series of three new alloys of nickel, iron, and titanium, Table 2, which might be classed as falling in the invar and elinvar group, was announced by the International Nickel Company in 1939. These alloys are divided into three groups: (*a*) the low-thermal-expansion group, (*b*) a high-thermal-expansion alloy, and (*c*) the constant-modulus-of-elasticity group. All of these alloys are of the precipitation-hardening type.

TABLE 2 COMPOSITION OF NICKEL-IRON-TITANIUM ALLOYS

	Ni	Ti	C_{max}	Mn	Si	Al	Cr	Fe
Group (*a*)	41	2.4	0.06	0.4	0.3	0.4	...	Remainder
	46	2.4	0.06	0.4	0.3	0.4	...	Remainder
	52	2.4	0.06	0.4	0.3	0.4	...	Remainder
Alloy (*b*)	29	2.4	0.06	0.4	0.5	0.4	8.5	Remainder
Group (*c*)	42	2.4	0.06	0.4	0.5	0.4	5.4	Remainder
	42	2.4	0.06	0.4	0.5	0.4	4.6	Remainder
	42	2.4	0.06	0.4	0.5	0.4	6.3	Remainder

The group (*a*) alloys have minimum coefficients of thermal expansion of 0.000002, 0.0000033, and 0.000005, respectively. Alloy (*b*) has a mean coefficient of thermal expansion from room temperature to 1000 F, of about 0.0000105 per deg F. It is not constant throughout the range, being somewhat lower at the lower temperatures and somewhat higher at the opposite end. The combination of these two alloys is well suited for use in "bimetal" strip. The third alloy group (*c*) shows in the order just listed no change in modulus of elasticity with change in temperature, an increase in modulus of elasticity with increased temperature, or a decrease in modulus of elastic-

ity with increased temperature, according to the composition under consideration.

FLAME TREATING

Direct application of the oxyacetylene flame to provide the heat for softening or hardening is an old conception but it came into general use only within the past 10 years. One of the early applications was that of treating pieces that were too large to place in any furnace. Portable equipment was used, the flame being applied directly to a small area to bring it up to the required heat, whereupon it was quenched by use of water spray for hardening, or cooled slowly for softening. As the practice came into use, its advantages of local treating became more obvious, and it found its way into the local treatment of smaller parts also. A typical case might be cited in the hardening of gear teeth, while leaving the body of the gear untreated. Many production plants are now using more or less automatic equipment for flame-heating and quenching of such parts. Automatic equipment is also being used for advancing the flame progressively, and the quenching spray for treating very large surfaces. The latest application of the open flame is to the descaling of large areas prior to painting of steel.

(To be continued)

BIBLIOGRAPHY

GENERAL

1 "ANC-5 Strength of Aircraft Elements," and Amendment 1, Government Printing Office, October, 1943.

2 A.S.T.M. Standards—Part 1—Metals (and Supplements), American Society for Testing Materials, 1943.

3 "Metals Handbook," American Society for Metals, Cleveland, Ohio, 1939.

4 "Metals & Alloys Data Book," by S. L. Hoyt, Reinhold Publishing Corporation, New York, N. Y., 1943.

5 "U. S. S. Carilloy Steels," Carnegie-Illinois Steel Corporation, Pittsburgh, Pa., 1938.

6 "S.A.E. Handbook," Society of Automotive Engineers, New York, N. Y., 1944.

7 "Materials and Processes," by J. F. Young, John Wiley & Sons, Inc., New York, N. Y., 1944.

8 "Materials Handbook," by G. S. Brady, fifth edition, McGraw-Hill Book Company, Inc., New York, N. Y., 1944.

9 "Powder Metallurgy," by John Wolff, American Society for Metals, 1942.

10 *Metal Progres*, Annual Reference Issue, October, 1944.

11 "Mechanical Properties of Metals and Alloys," National Bureau of Standards, Circular C-447, Government Printing Office, 1943.

12 "The Oxy-Acetylene Handbook," Linde Air Products, Division of Union Carbide & Carbon Corp., New York, N. Y., 1943.

13 "Contributions of Metallurgy to Engineering Progress," by W. R. Barclay, MECHANICAL ENGINEERING, vol. 60, Aug. and Sept., 1938.

14 "Effect of Low Temperatures on the Properties of Aircraft Metals," by S. J. Rosenberg, Research Paper RP-1347, National Bureau of Standards, Dec., 1940.

NATIONAL EMERGENCY STEELS

15 "Possible Alternates for Nickel, Chromium and Chromium-Nickel Constructional Alloy Steels," American Iron & Steel Institute, Contribution to the Metallurgy of Steel, no. 5, Jan., 1942.

16 "The National Emergency Steels NE8000 Series," American Iron and Steel Institute, Contribution to the Metallurgy of Steel, no. 7, Aug., 1942.

17 "Mechanical Properties of NE9400, 9500 and 9600 Series," American Iron and Steel Institute, Contribution to Metallurgy of Steel, no. 10., March, 1943.

18 "The N.E. Steels in the Post-War Era," by Edwin F. Cone, *Metals and Alloys*, May, 1944, p. 1122.

19 "Mechanical Properties of N.E., S.A.E., and Other Hardened Steels," by W. G. Patton, *Metal Progress*, May, 1943, p. 726.

20 "Relative Effect of Elements on Alloy Steels," by J. Mitchell, *Metal Progress*, July, 1942, p. 53.

21 "Machinability of the National Emergency Steels," by O. W. Boston, *Metal Progress*, April, 1943, p. 543.

22 "National Emergency Alloy Steels, Revised to May 26, 1944," *Metal Progress*, July, 1944, p. 96B.

23 "S-Curves for Six N.E. Steels," Data Sheet compiled by U. S. Steel Research Laboratory, *Metal Progress*, Aug., 1944, p. 304-B.

24 "N.E. Steels in Oil-Well-Drilling Equipment," by B. B. Wescott, *Metal Progress*, Aug., 1944.

ISOTHERMAL TRANSFORMATION AND INTERRUPTED QUENCHES

25 "Transformation of Austenite at Constant Subcritical Temperatures," by E. S. Davenport and E. C. Bain, Technical Publication No. 348, American Institute of Mining & Metallurgical Engineers, 1930.

26 "Heat-Treatment of Steel by Direct Transformation From Austenite," by E. S. Davenport, *Steel*, March 29, 1937.

27 "The Process and Result of Austenite Transformation at Constant Temperature," *Metals and Alloys*, January, 1937.

28 "Austempering on Production Basis," by D. R. James, *Iron Age*, Aug. 31, 1939.

29 "The Industrial Application of Austempering," by E. E. Legge, *Metals and Alloys*, Aug., 1939.

30 "Improved Tempering," *Steel*, Sept. 4, 1939.

31 "Hardness but With Toughness," U. S. Steel Corporation, National Metal Congress, Cleveland, Ohio, 1940.

32 U. S. Patent 1,924,099, "Thermally Hardening Steel," by E. C. Bain and E. S. Davenport, Aug. 29, 1933.

33 "Atlas of Isothermal Transformation Diagrams," publication of U. S. Steel Corporation of Delaware, Pittsburgh, Pa., 1943.

34 "Martempering Technique Based on Precise Control," by H. J. Read, review of B. F. Shepherd paper, *The Review*, American Society for Metals, Nov., 1943.

35 "Isothermal Quench Baths Applied to Commercial Practice," by H. J. Babcock, *Iron Age*, Feb. 4 and 10, 1944.

36 "Interrupted Quench in Salt," *Houghton Line* No. 13, March, 1944, E. F. Houghton Company, Philadelphia, Pa.

37 "Improved Processing Methods Help Avoid Heat-Treating Distortion," by G. W. Birdsall, *Steel*, May 15, 1944, p. 86 (lists treatment rules for avoidance of distortion).

38 "Martempering," by B. F. Shepherd, *Iron Age*, Jan. 28, 1943; Feb. 4, 1943.

39 "Final Casing of High-Speed-Steel Tools," reprint from *Houghton Line*, July, 1943, E. F. Houghton Company, Philadelphia, Pa.

40 "Planning Heat-Treatment by S-Curves," by R. L. Rickett, *Metal Progress*, Jan., 1943.

41 "Timed Quenching," by M. L. Frey, *Metal Progress*, Aug., 1944.

42 "Martempering," by B. F. Shepherd, *Metal Progress*, Aug. 1944.

43 "Hot Quenching and Austempering," by H. J. Elmendorf, *Metal Progress*, Aug., 1944.

COLD TREATMENT OF STEEL

44 "The Cold Treatment of Certain Alloy Steels," by G. V. Luerssen and O. V. Greene, Trans. American Society for Steel Treating, vol. 19, 1932.

45 "The Transformation of Retained Austenite in High-Speed Steel at Subatmospheric Temperatures," by Paul Gordon and Morris Cohen, Trans. A.S.M., Sept., 1942.

46 "Sub-Zero Stabilizing of Steel Gages and Parts," by H. A. Knight, *Metals and Alloys*, March, 1944, pp. 610–614.

STEEL HARDENABILITY CALCULATED FROM COMPOSITION

47 "Hardenability of Steel Calculated From Chemical Composition," by M. A. Grossman, Trans. A.I.M.E., vol. 150, 1942, p. 227.

48 "Hardenability of Steel Calculated From Chemical Composition," digest of ref. 47, by M. A. Grossman, *Metal Progress*, July, 1942, p. 80.

49 "Nomogram for Calculating Hardenability," by C. K. Donoho and W. W. McCulloch, *Metal Progress*, Sept., 1943, p. 440-D (nomogram for simplifying the calculation of hardness from composition; based upon Grossman methods).

50 "How to Estimate Hardening Depth in Bars," by J. L. Lamont, *Iron Age*, Oct. 4, 1943.

51 "Effect of Silicon on Hardenability," by W. Crafts and J. L. Lamont, Trans. A.I.M.E., vol. 154, 1943, p. 386.

52 "Effect of Sixteen Alloying Elements on Hardenability of Steel," by I. R. Kramer, R. H. Haffner, and S. L. Tolman, *Metals Technology*, Sept., 1943.

53 "Effect of Some Alloying Elements on Hardenability," by W. Crafts and J. L. Lamont, *Metals Technology*, Jan., 1944.

HIGH-STRENGTH CAST IRONS AND CAST STEELS

54 "Improvements in Steel Foundry Methods," by G. A. Lilliequist; "High-Strength, High-Ductility Cast Steels," by C. F. Joseph; and "High Strength Cast Iron," by G. L. Rochter, *Metal Progress*, April, 1944.

55 "Nickel Cast Iron Data: Section No. 1," International Nickel Company, New York, N. Y., 1940.

56 "Molybdenum in Gray Iron: Sections II and III," Climax Molybdenum Company, New York, N. Y., 1940.
57 A.S.T.M. Specification A-48-41, Gray Iron Castings.
58 A.S.T.M. Specification A-48-36, Alloy Steel Castings for Structural Purposes.
59 "Trends in Iron Foundry Metallurgy," by J. S. Vanick, *Metal Progress*, Jan., 1944.
60 "Molybdenum Cast Steels," Climax Molybdenum Co., New York, N. Y., 1940.

LEADED STEELS

61 "Character and Machine Performance of Lead-Bearing Steels, by F. J. Robbins, *Iron Age*, Nov. 17, 1938, p. 28.
62 "Properties of Some Free-Machining, Lead-Bearing Steels," by J. H. Nead, C. E. Sims, and O. E. Harder, *Metals and Alloys*, March and April, 1939.

GRAPHITIC STEELS

63 "Developments in Graphitic Steels," by F. R. Bonte and Martin Fleischmann, *Metal Progress*, April, 1937.
64 "Die Costs Cut With Graphitic Steels," by F. R. Bonte, *American Machinist*, March 10, 1937.
65 "Graphitic Steel—Its Fabrication, Heat-Treatment and Applications to Dies and Punches," by G. A. Stump and F. R. Bonte, *Steel*, August 30, 1937.
66 "Reducing Die Costs by Using Graphitic Steel," by W. G. Kifer, Paul Abel, and F. R. Bonte, *Machinery*, Oct., 1937.
67 "Die Design," by Ward Kifer, *Iron Age*, Jan. 9, 1941.
68 "Graphitic Steels," by F. R. Bonte, *Steel*, Nov. 24 and Dec. 1, 1941.
69 Timken Graphitic Steel Booklet, Eighth edition.

BORON STEEL

70 "Boron," by T. W. Lippert, *Iron Age*, Nov. 19, 1942.
71 "Report on Special Alloy Addition Agents," A.I.S.I. Contribution to Metallurgy of Steel, No. 9, Nov., 1942.

ZIRCONIUM-BEARING AND COLUMBIUM-BEARING IRON AND STEEL

72 "Effect of Molybdenum and Columbium on the Structure, Physical Properties and Corrosion Resistance of Austenitic Stainless Steels," by R. Franks, W. O. Binder, and C. R. Bishop; paper presented before American Society for Metals, Oct., 1940.
73 "Physical Properties of High-Nitrogen Chromium and Chromium-Nickel Steels and Columbium-Bearing Chromium-Nickel Steels," publication of Electro Metallurgical Company, New York, N. Y., 1936.
74 "Effects of Columbium in Chromium-Nickel Steels," by F. M. Beckett and R. Franks, Trans. A.I.M.E., 1934.
75 "Machinable 1.5% and 2.0% Chromium Cast Irons to Resist Deterioration at High Temperatures," by C. O. Burgess and A. E. Shrubsall, Technical Publication no. 42–27, American Foundrymen's Association, 1942.

NITROGEN AS AN ALLOYING ELEMENT IN STEELS

76 "Nitrogen in Chromium Alloy Steels," publication of Electro Metallurgical Company, New York, N. Y., 1941.
77 "Chromium Steels of High Nitrogen Content," by R. Franks, paper presented before A.S.M., Sept.-Oct., 1935.
78 "Nitriding Ferroalloys," by R. H. Steinberg and D. Steinberg, *Metals and Alloys*, April, 1944, p. 859.

NITRIDE CASEHARDENING OF STAINLESS STEELS

79 "Nitriding Properties of Some Chromium and Austenitic Steels at a Temperature of 500° C," by Jones, Iron and Steel Institute, Carnegie Memoirs, London, vol. 22, 1933, p. 51.
80 "Process for Surface Hardening Stainless Steels," Bulletin 21, Drever Company, Philadelphia, Pa., 1943.
81 "Nitralloy and the Nitriding Process," Nitralloy Corporation, New York, N. Y., 1943 (booklet on Nitralloy and only partly applicable to nitriding of other steels).
82 "Nitriding of Austenitic Steels," *Metals Handbook*, 1939 edition, p. 1072.

SILICON IMPREGNATION OF STEEL

83 "Silicon Impregnation of Iron and Steel," by H. K. Ihrig, *Metal Progress*, vol. 33, no. 4, 1938, p. 367.
84 "Silicon Impregnation," by H. K. Ihrig, *Metals Handbook*, 1939 edition, p. 1090.

NEW MAGNETIC ALLOYS

85 "Iron-Nickel Alloys for Magnetic Purposes," Nickel Alloy Steels Section IV, data sheet no. 2, International Nickel Company, New York, N. Y., April, 1939 (general data).
86 "Alnico Properties and Equipment for Magnetization and Test," by B. M. Smith, *General Electric Review*, April, 1942.
87 "Permanent Oxide Magnet and Its Characteristics," Kato and Takei, *Journal*, Institute of Electrical Engineers of Japan, 1933, p. 408.
88 "New Magnetic Materials," by W. E. Ruder, Proc. Institute of Radio Engineers, vol. 30, Oct., 1942, p. 437 (includes information on treatments).
89 "Silica Strip Steel," E. D. Treanor, *Electrical Engineering*, vol. 57, 1938, p. 622.
90 "Influence of Improved Magnetic Alloys on Design Trends of Electrical Instruments," *Electrical Engineering*, March, 1944 (includes tables of properties of new alloys).

NICKEL-IRON-TITANIUM ALLOYS

91 "Dispersion Hardening Alloys of Nickel and Iron-Nickel-Titanium," by N. B. Pilling and A. M. Talbot, American Society for Metals, Symposium on Age Hardening of Metals, 1939, pp. 231–257.

FLAME TREATING

92 "Surface Hardening With the Oxy-Acetylene Flame," by A. K. Seemann, *Metal Progress*, Sept., 1937.
93 "Oxy-Acetylene Surface Hardening," by A. K. Seeman, MECHANICAL ENGINEERING, vol. 60, July, 1938.
94 "The Oxy-Acetylene Handbook," chapt. 33, published by Linde Air Products Company, New York, N. Y., 1943.
95 "Flame-Treating," by J. H. Zimmerman, *The Welding Journal*, February, 1940.
96 "Flame Hardening Standardization," by A. L. Hartley, *Iron Age*, Oct. 17, 24, 31, Nov. 7, 14, 1940.
97 "Putting Flame Hardening to Work," by G. T. Williams, *Metal Progress*, March, 1944.
98 "Practical Application of Flame Hardening," by A. L. Hartley, MECHANICAL ENGINEERING, vol. 64, 1942, pp. 531–540.

They Help to Make Engineer Officers

(*Continued from page 100*)

valuable contribution to the supply of technically trained young officers for this war.

In 1938 the Council of the Institution, appreciating the part which mechanical engineers would have to play in rearmament, decided to investigate the extent to which its members were equipped to serve the country in rearmament and in the event of war. They therefore formed a register classifying the experience and attainments of its members which was to be at the service of the Government. The importance of the possibilities presented by such a register was immediately appreciated by the Ministry of Labor who, using it as a model, decided to register the whole of the engineers and scientists of professional grade in the country.

From the earliest days of the war, mechanical engineers were "reserved," their employment and movements being under the control and direction of the Ministry of Labor and the Ministries concerned with production of war material and fighting services. Consequently, almost the whole of the membership of the Institution has been, and is, engaged in war activities under the direction of the appropriate Government authority, either in the fighting services, or in the production, research, and development organizations which serve the fighting forces.

While the majority of the war work of the members of the Institution is in either industry concerned with war material, or in Government Departments concerned with war material, over 3000 members are serving in the engineering sections of the fighting services in the Army, Navy, or Air Force.

Trends in the Use of WELDED MACHINERY PARTS

By EDWARD J. CHARLTON

ASSISTANT TO PRESIDENT, LUKENWELD, INC., COATESVILLE, PA.

THIS discussion of trends in the use of welded machinery parts will be limited to components fabricated from low-carbon hot-rolled steel and its related alloys. The topic is timely, for the use of welded machinery parts is about to enter what is perhaps the most important stage in its growth. As a broad and fundamental trend, this use over a period of roughly 15 years since its inception has gained the status of general acceptance for welded machinery parts.

If it can be said that the utilization of this new type of construction has aided our war effort, we can be thankful that service records in many prior applications proved the effectiveness of weldments. Not only have these records served to prove the adequacy and engineering value of welded machinery parts but also from these service records in diverse fields, certain convictions or assumptions in design philosophy have been substantiated, particularly under operating conditions embracing fatigue and impact.

One weldery alone, dating from 1930, has produced or collaborated in the design of welded-steel machinery parts for nearly 700 different users in 15 industries. These parts have gone into service in 28 states as well as in foreign lands.

The basic impetus behind this general acceptance can be accounted for by economic and engineering considerations.

An additional impetus during the war years has been an abnormal urge to acquire necessary parts by any means, as quickly as possible, with the result, that many times, normal economic justification must have been nonexistent. Doubtless the spread in use of fabricated parts has been accelerated simply because trial samples or educational designs embodied them. During the war period, great quantities of duplicate weldments have been fabricated while under normal conditions the investment necessary for plants, tooling, and other equipment to produce these parts might have awaited economic justification.

WELDERIES HAVE DEVELOPED INDUSTRIALLY

As a result, we will enter the postwar period with existing welderies taking definite forms as industrial units scattered throughout the nation, with many of them devoted exclusively to production of machinery parts. Already some have developed as subsidiaries supplying parts to plants producing finished machinery. Others are an outgrowth of plants previously engaged in quite different types of fabrication. Still a third group has specialized solely in the production of welded machinery parts. Such growth and development is in contrast to that of the foundry industry.

It is impossible to discuss this subject of welded parts practically, without contrasting its aspects often with those of the foundry industry, because structural parts of machinery traditionally have been castings. However, no implication is intended in this paper that competition between the foundry and the weldery should exist.

Drawing a comparison with the foundry industry, we see the use of cast iron growing steadily in step with the progressive mechanization of industry. Cast steel entered the field as a material vastly superior in its physical properties to any the existing iron. The steel foundry clearly is a child of necessity.

By contrast, the use of welded parts was inaugurated with no clear-cut apparent general necessity. Traditional media for producing structural mechanical parts did exist. Hence relatively fine lines of distinction from standpoints of economics and engineering had to be developed. These distinctions were established on the design philosophy of full utilization of the superior properties of rolled steel, with the result that an engineering service has developed of necessity as a part of this new industry.

That future trends in the use of welded machinery parts will be based on well-equipped existing welderies is a foregone conclusion, and they will compete by every legitimate means to maintain themselves. Wartime production will affect these trends by providing broad statistical service records which have been made under most drastic conditions imaginable. Basic cost data will be available in addition to existing experience in design, methods, and quantity tooling. This accelerated development can be compared with prewar conditions, when contracts covered small quantities. In those years, the complete exploitation of the process by production tooling was not justified.

On the other hand, undoubtedly much misuse of weldments has resulted because of war necessity. Instances of their application because of scarcity of other materials must exist. Criteria established by battle damage possibly have introduced the use of weldments in applications not justified commercially. Inevitably with respect to such applications the trend will be toward reversion to the use of castings.

Without doubt, certain changes in design criteria are due, for weldments have been applied to machines, the over-all design of which was frozen for one reason or another. Possible superior advantages have been submerged in such applications. Unless the machines are redesigned to realize the full value of welded construction, reversion might occur.

BASIC REASONS FOR TRENDS

Several basic reasons for normal trends in the use of welded parts apply to the selection of any engineering material, and they reflect either economic or engineering concepts or a combination of the two. These reasons are comparative first cost, predictability, strength characteristics, need for greater rigidity, weight reduction, wearability, operating efficiency, and natural adaptability.

These factors determine the selection of a material or process, and usually one of them dominates, with the other as lesser influences.

Cost Is Fundamental. Comparative initial cost is the first on our list of reasons.

If the design is adequate, if it is economical, if possible indirect economies have been considered in cost comparisons, if the specifications are clear and conclusive, this fundamental reason loses its engineering significance. It becomes purely an economic consideration and a function of the Purchasing Department.

Predictability Is Insurance. The second of our reasons is pre-

Contributed by the Metals Engineering and Production Engineering Divisions and presented at the Annual Meeting, New York, N. Y., Nov. 27–Dec. 1, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

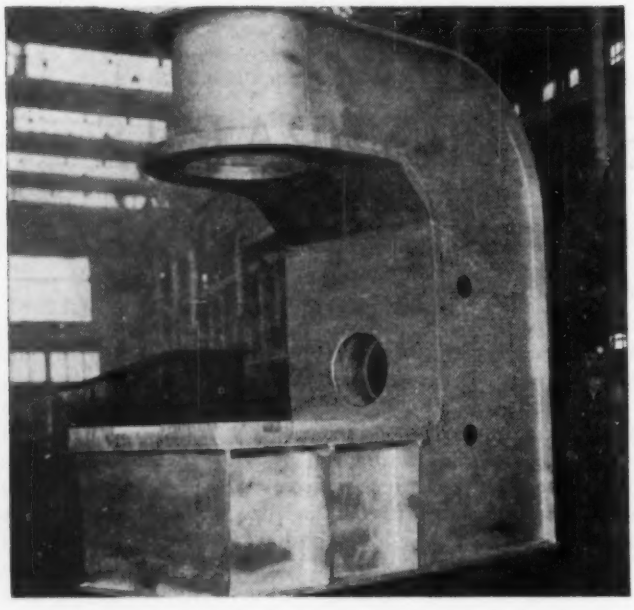


FIG. 1 HOUSING FOR 255-TON JOGGLING PRESS USED FOR CRIMPING EDGES OF PLATES

(This housing measures 10 ft 8 in. long by 4 ft 8 in. wide by 11 ft 6 in. high and weighs 33,040 lb.)

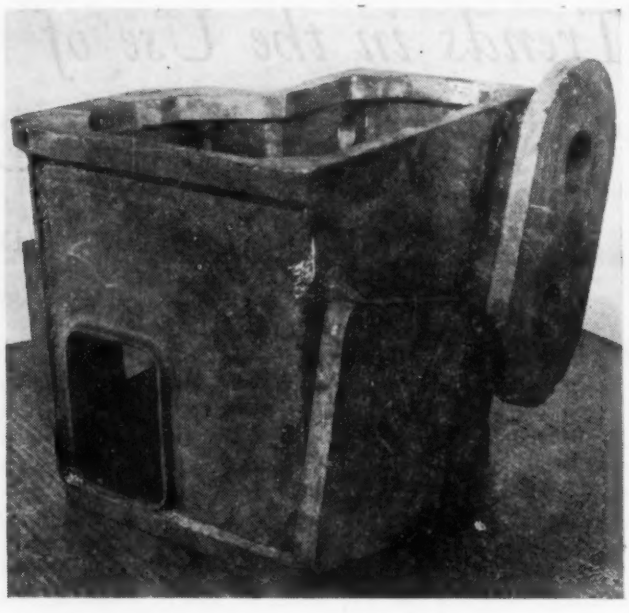


FIG. 2 GEAR HOUSING, A WELDMENT WHICH IS PRODUCED BY THE HUNDREDS

(The weldment is justified because of its higher degree of predictability or its reduction in repair time, over former type of construction.)

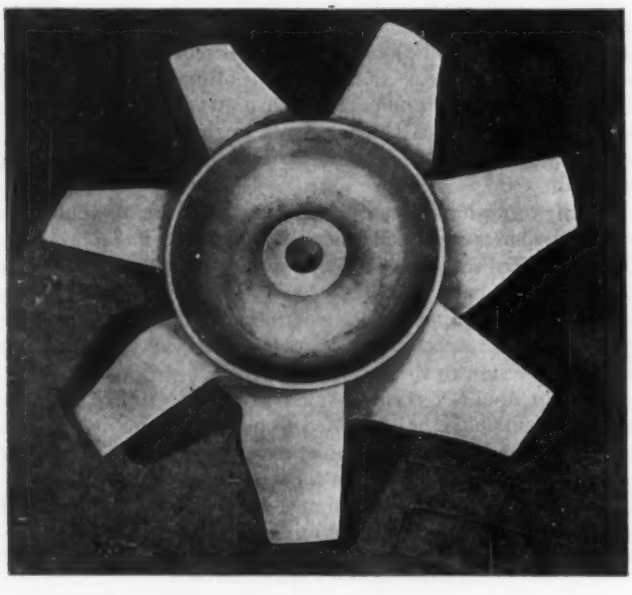


FIG. 3 HIGH-SPEED BLOWER FAN, COMPOSED OF CENTRAL FORGING WITH FORGED VANES WELDED TO IT

(These fans operate at 5000 rpm and are tested at 7500.)

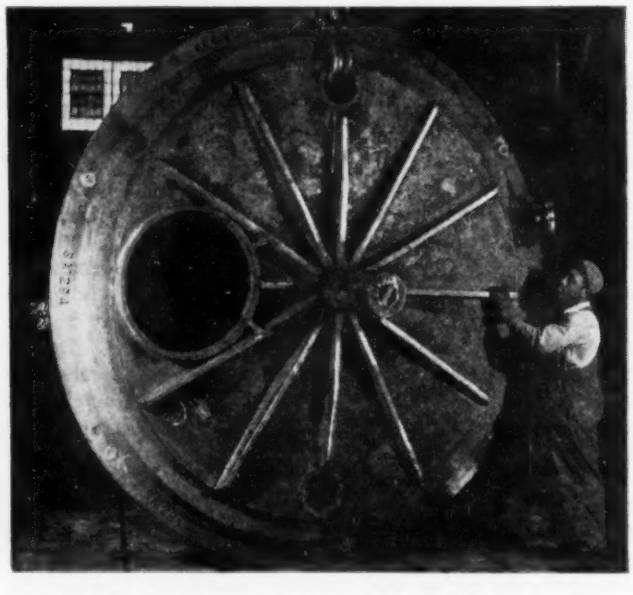


FIG. 4 END PORTION OF ROTARY MIXING UNIT IN A CHEMICAL PROCESS, WHICH IS IN CONTINUAL OPERATION

(The central, or hub section, and the rim are of cast steel. Rest of construction is steel plate. Head is 9 ft $8\frac{1}{2}$ in. OD, weighs about 6000 lb.)

dictability. This can be a matter of insurance as in the open-side press frame, Fig. 1. This weldment replaced a fractured cast frame in an existing press which had been in operation for a relatively short time. It was installed several years prior to the war.

Such insurance is an economic reason justifying the use of a new type of structure. If the first cost of the weldment exceeded that of the casting, the premium can be considered as that on an insurance policy against failure. Machining, installation, and loss of production while the replacement was being built also are cost factors. An obvious trend exists here since weldments are being widely used in such heavy machinery.

Another item involving predictability is rejection or scrappage. Fig. 2 shows a gear housing which has been produced by the hundreds. It is hard to conceive that its first cost could compete with that of a casting. The use of this weldment stems from the alleged expenditure of an average of 75 hr for repair on each such casting. This may seem an exaggeration, but on the other hand, it may not since magnaflux was used as an inspection method on both casting and weldment. At any rate, the user of this part apparently feels that a weldment is justified because of its higher degree of predictability.

The weldery cannot be held responsible for "stealing" this item from the steel foundry since the user was about to substitute bronze when the weldment entered the picture.

A report on the repair time states that the alleged 75 hr previously necessary have been reduced to 1 or 2 hr on the weldment.

Another element, relatively unimportant in predictability, is that on large pieces, less metal need be removed in machining.

The author has observed $^3/_4$-in. to 1-in. stock being machined from steel castings of large dimensions. Yet weldments of such size can be produced with an allowance of $^3/_8$ in.

All these factors involving predictability in the trend of weldment use have only economic significance.

A factor of engineering significance is consistent predictability required by severe operating conditions. The high-speed blower fan, Fig. 3, is composed of a central forging with drop-forged vanes welded to it. These fans, operating at 5000 rpm and tested at 7500, were used for several years prior to the war.

Obviously, the inherent soundness of the forged and welded steel is considered to constitute insurance against failure which would be very serious at the speeds indicated.

Comparative Strength Characteristics. The third reason behind the trends which we are discussing is the comparative strength characteristics of competing materials.

Fig. 4 shows the end portion of a rotary mixing unit, many of which are in operation in a chemical process. The original design used steel castings and properly so, for at that time weldments as machinery parts did not warrant consideration since too little was known about their design. The castings failed consecutively following a limited service life. Repairs were attempted unsuccessfully so that replacement became a somewhat normal procedure. The difficulties of shape and size limitations apparently were such that a steel casting of designed strength was not possible.

Finally, attempting to avoid continual replacements, the user considered a weldment. The piece shown is the result which has now become standard in this application. The original installation has been in service for more than 5 years and no replacements have been necessary. No change in the mechanical design was needed; the weldment simply replaces the casting within the size and clearance limitations imposed.

A substantial part of the welded structure remains a steel casting. Castings were used in the design where economical, as well as to obtain flowing contour inherent in a casting at points where such is desirable.

We have here a profound difference in the concept of applying castings. The castings used in this part are of such size and shape as to be desirable and readily produced in the foundry. This is in contrast to the difficult production features of the entire piece as a single casting.

Two things are apparent here in connection with comparative strength characteristics: (1) steel plate has been substituted in the large flat expanses involved, and (2) the concept of welding has permitted the elimination of the fundamentally weak points. The piece is broken into small components of predictable strength; integrated with welds of predictable strength.

In such a mechanical part, a comparison of physical properties applicable to static loading conditions is not adequate. Repetitive and reversed loading occurs, and the endurance limit of the structure becomes the controlling criterion. There is a trend toward making the endurance limit and impact resistance definitely specified properties of materials to be used in the structural parts of machines.

Much has yet to be established by research, regarding such properties. Our knowledge regarding phenomena resulting from multiaxial stresses is limited also. However, the progressive accumulation of such knowledge will promote meticulous care in design and production so that present-day castings or weldments will seem crude in shape and quality by comparison.

Maximum Rigidity Considered. The fourth reason behind the trends in the use of weldments is maximum rigidity, and this must be considered within definite weight and space limitations. Maximum rigidity so limited obviously can be realized only by disposing material with the highest possible modulus of elasticity in the most effective manner. Expressed simply, there is no question but that an iron casting is more rigid if it weighs enough or is sufficiently larger in cross section.

The foregoing remarks may seem elementary, but they are made because the repeated assertion in the early days of welded steel, that cast iron is stiffer, is still heard occasionally.

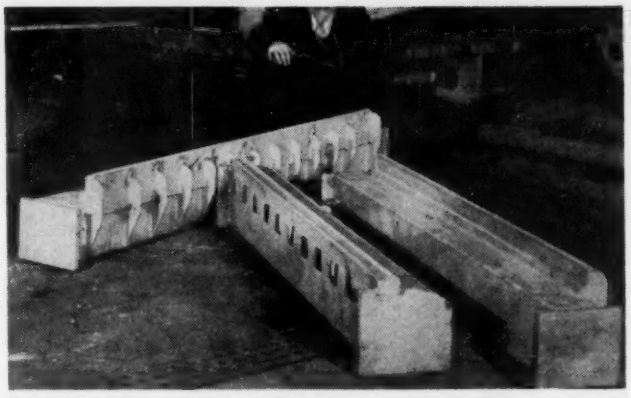


FIG. 5 KNIFE BEAM OF WELDED STEEL, WHICH MOVES AT HIGH SPEED IN A RECIPROCATING MOTION

(It is about 7 ft long with a cross section approximating 8 × 9 in., and with walls $^3/_{16}$ in. thick.)

FIG. 6 CONVENTIONAL BED FOR A MACHINE ASSEMBLY

(The primary members of underside stiffener diagonals are closed box sections.)

The welded part, shown in Fig. 5, was redesigned into welded steel many years ago. It is about 7 ft long with an approximate cross section of 8 × 9 in. In welded steel its walls are $^3/_{16}$ in. thick. Clearly with such thinness it is lighter in weight than any design possible as a casting. Its function demands maximum rigidity, but minimum weight is desirable also. It moves at high speed in a reciprocating motion.

Fulfillment to a higher degree of the necessities just mentioned was provided by the weldment, and greater operating efficiency resulted.

Fig. 6 is a conventional bed for a machine assembly. Since its over-all depth is limited, the user sought maximum rigidity within this restriction. The maximum is provided therefore within the extent of our knowledge of materials by steel disposed in an effective manner. The stiffeners on its under side are diagonal, and the primary members are closed box sections. The thickness of metal is dictated only by design considerations.

Weight Reduction. Our fifth reason in the selection of a structural part is weight reduction. This reason has established to a great degree the trend in the use of weldments. Weight is a watchword in transportation equipment with current emphasis on increased speed, safety, and operating efficiency.

The item shown in Fig. 7 is typical of many relatively unimportant or prosaic fittings applied on the decks of maritime vessels of all types. Traditionally, they were castings of greater over-all weight. If they can be produced as castings at equal weight they will revert ultimately if prices are competitive.

Of the two items shown in Figs. 8 and 9, the one in Fig. 8 is

FIG. 7 MOORING BITTS USED FOR MARITIME PURPOSES
(The parts were pressed and the pipe assembled and welded to the tops and the bases.)

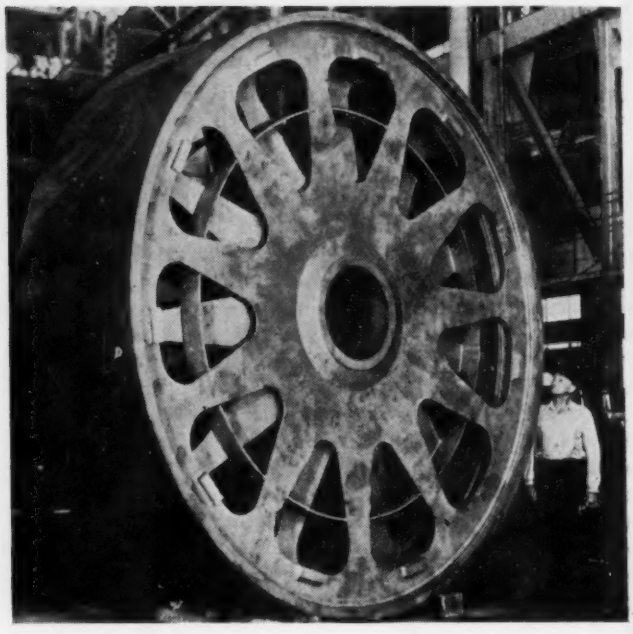


FIG. 8 SECOND-REDUCTION GEAR BLANK FABRICATED BY WELDING
(This gear blank weighs 25,000 lb, measures 12 ft $11\frac{1}{4}$ in. OD, and has 3 ft $4\frac{3}{4}$ in. face.)

FIG. 9 UPPER CASE FOR HOUSING SPEED-REDUCING GEARS
(Of all-welded steel construction, weighs 42,000 lb and is 18 ft 6 in. wide by 8 ft 8 in. long by 7 ft $10\frac{5}{16}$ in. high.)

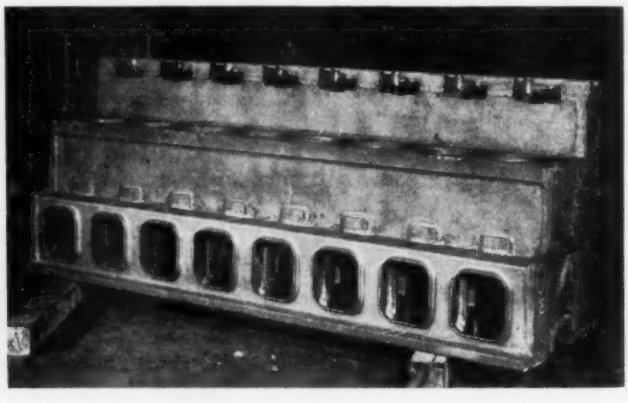


FIG. 10 FRAME FOR EIGHT-CYLINDER ENGINE
(This frame measures 6 ft 10 in. long by 2 ft 7 in. wide by 2 ft high and weighs approximately 2065 lb.)

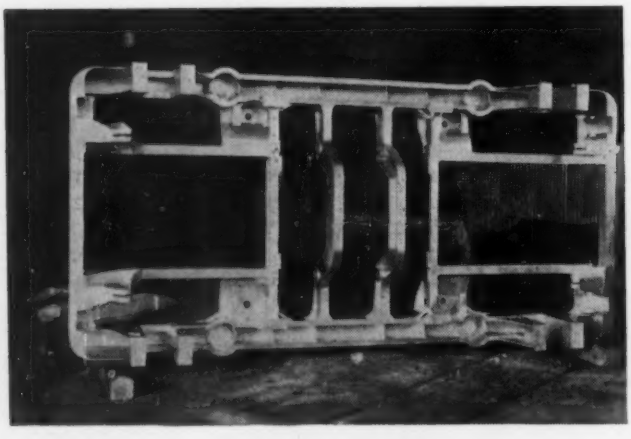


FIG. 11 WELDED STEEL TRUCK FRAME WEIGHING 3950 LB
(The over-all dimensions of the frame are 15 ft long by 7 ft 6 in. wide by 2 ft 3 in. high.)

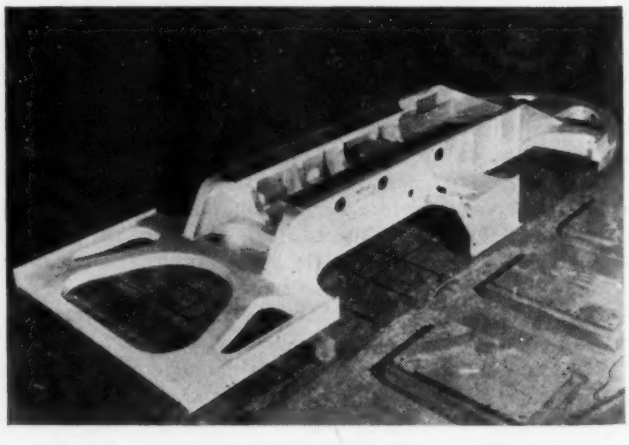


FIG. 12 WELDED STEEL ENGINE USED ON A RAILROAD MOTIVE-POWER UNIT
(The completed engine bed, weighing 3 tons, supports 30 tons of load.)

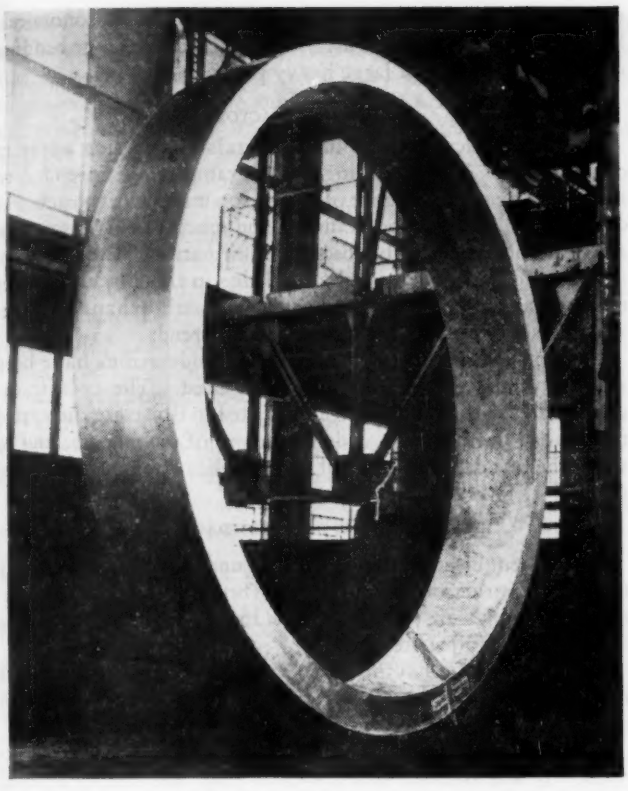


FIG. 13 RIDING RING FOR USE ON ROTARY KILN
(Ring measures 12 ft OD by 10 ft 8 in. ID by 8 in. thick and weighs 12 tons.)

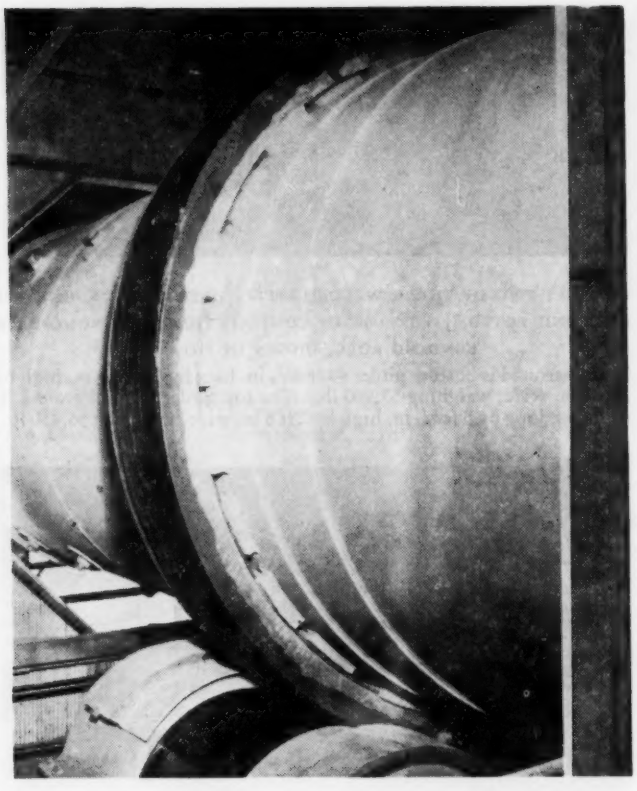


FIG. 14 CLOSE-UP OF RIDING RING IN USE AS A "TIRE" ON KILN, SHOWING ROLLERS ON WHICH RING RIDES

a gear blank, the other in Fig. 9, a housing of the same mechanism, both of which came into being in the search for minimum weight. They were used first as structural parts of marine drives on naval vessels in the days when "treaty limits" were the design basis for the Navy's ships. Such items replace castings of relatively enormous weight.

Apparently they show marked superiority in resisting the abnormal loads imposed by the explosive forces of battle damage, but they are also used extensively in cargo vessels.

Weight reduction dictates the engineering selection of construction for the Diesel-engine frame shown in Fig. 10. This frame is more complicated than it appears. Much of it is composed of metal $^3/_{16}$ in. thick, and such thin sections throughout its structure connect with much heavier sections in a somewhat abrupt manner. There are labyrinths in its shape involving many small enclosed pockets. Clearly, it would be difficult, if not impossible, to use any other known form of construction with less weight.

Thousands of these frames have been produced without question of predictability or design hazard. They are neither scrapped in production nor are they replaced due to service failure.

Another major form of transportation involving minimum weight in equipment is the railroad. Fig. 11 shows a car-truck frame fabricated mainly of hot-rolled plate $^3/_8$ in. and $^1/_2$ in. thick, respectively, with a few steel castings included. The user feels that 30 per cent has been saved in the weight of this frame.

Fig. 12 is a much publicized and ancient item of welded construction in railroad service. It is the entire foundation, 25 ft long, 10 ft wide, with the greater part of its structure $^1/_4$ in. thick, of the front end of the "Zephyr" type high-speed lightweight trains.

It is inconceivable that such a structure in one piece could be obtained by any other known method at equal or less weight.

Wearability. Wearability, the sixth point mentioned as es-

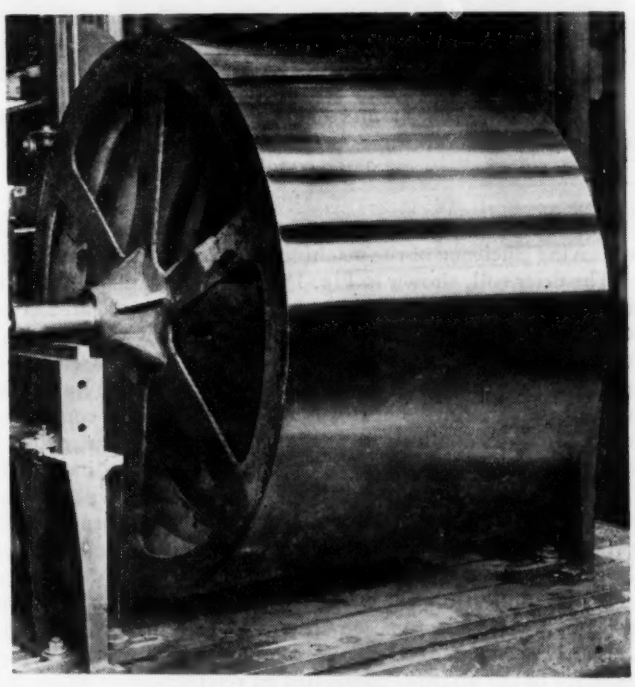


FIG. 15 WELDED STEEL DRIER CYLINDER, DESIGNED TO OPERATE AT 100 PSI OF STEAM
(Of double-shell type, it is 5 ft OD and has a 4-ft face; it weighs 4665 lb.)

tablishing trends in the use of weldments, is typified by the part shown in Fig. 13. It is a plate 8 in. thick, 23 in. wide, weighing 12 tons, formed in the bending rolls to a 12-ft circle and butt-welded. After finishing, these weldments are used as "riding rings" on rotary kilns. Wear naturally controls their service life, but they do not wear out as quickly as those previously used.

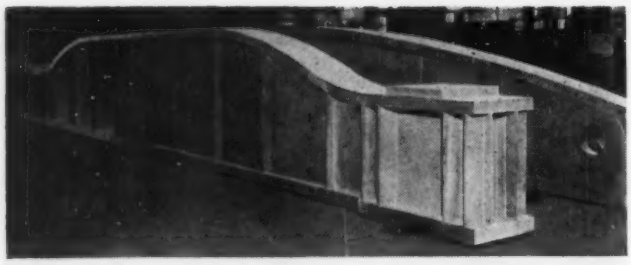


FIG. 16 TWO OF THREE WELDED STEEL GIRDER BEAMS, ONE TOP AND ONE BOTTOM, FOR USE IN CONSTRUCTION OF STRONG-BACK BENDING ROLL, SHOWN IN FIG. 17

(In foreground is bottom girder 49 ft 8 1/2 in. long by 5 ft 8 3/4 in. high by 2 ft 6 in. wide, weighing 57,980 lb. The top girder, in background, is 40 ft 8 in. long by 6 ft 3/4 in. high by 2 ft 6 in. wide, weighing 56,480 lb.)

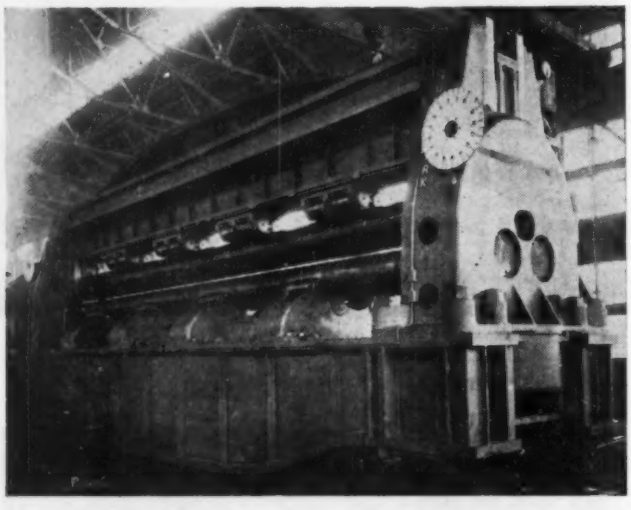


FIG. 17 STRONG-BACK BENDING ROLL USING THREE GIRDER BEAMS OF WELDED CONSTRUCTION, WITH A SCREWDOWN CAPACITY OF 2,400,000 LB

Increased Operating Efficiency. The seventh reason is increased operating efficiency of the machine in which the parts are used.

The drier roll, shown in Fig. 15, is an important advance in the use of welded machinery parts. It is a steam-heated drier used in the paper, printing, drug, and textile industries. Traditionally of cast iron, at least 250 welded steel driers are now in use, some of them for more than 10 years. They are lighter in weight than castings, but this is not usually a prime consideration. In one application steam consumption was reduced approximately 40 per cent, and yet production was increased. The thickness of the outer shell on the drier shown is approximately 1/2 in. The drier operates under a steam pressure of 100 psi. The replaced iron drier, with much thicker shell, carried 20 psi of steam.

In one application, the weldment directly replaces a cast-iron drier in a paper machine which was long in operation. Production was increased to a large extent because the initial drying capacity of the machine controlled its productivity. Since the installation of the weldment, another part of the machine has become the bottleneck.

Natural Adaptability. The final item establishing trends is natural adaptability, that is, the suitability of a welded structure to design requirements. In the foreground of Fig. 16 is a typical example of a beam weighing approximately 30 tons. Roughly it is 50 ft long and 6 ft high with flanges 5 in. thick, and web plates 7/8 in. thick.

It seems obvious that this form of construction is most suitable for parts of this nature. Clearly, riveted construction would not be more adaptable or economical. It is not likely that castings in either steel or iron would be more economical. Fig. 17 shows this beam in use. The machine is a huge bending roll for the forming of large heavy plates.

ELEMENTARY FACTORS

In most applications the fundamentals of selection apply in combination. The foregoing eight examples are intended to illustrate the predominance of the reason under which each was described. Many of the examples and much of this discussion are well known, possibly obsolete, information. The intention is not to add to fundamental knowledge in this discussion, but to pause at this point of impending industrial change and review these elementary factors behind the trends.

Developments induced by wartime considerations have been avoided deliberately in the examples cited. The prosaic examples that we have shown were selected to illustrate the varied reasons for the current trends in the use of weldments, and to show the breadth and depth of their application in many industries.

ENGINEERING IS BASIC FUNDAMENTAL

Certain engineering fundamentals underlie the use of any type of construction or material. The basic fundamental behind the trends in the use of weldments is the engineering utilization of rolled steel.

Such utilization may involve simple supports, such as those in Fig. 18, or it may involve a relatively complex structure, such as shown in Fig. 19.

Early weldments were considered practically as riveted structures. It was assumed that a welded joint was simply a joint. A pure butt weld was considered a hazard and structures were designed to avoid them.

Electrodes, equipment, and technique have developed pro-

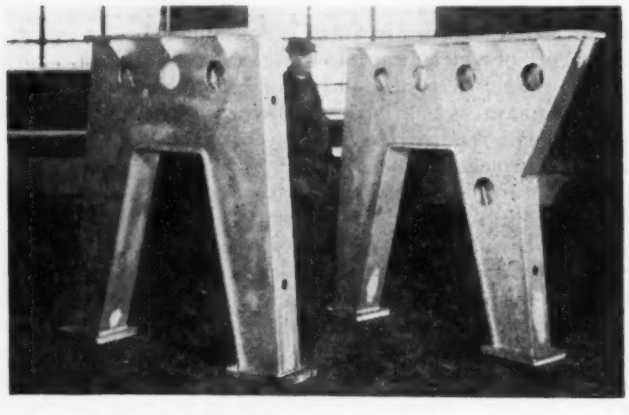


FIG. 18 WELDED STEEL PARTS FOR PAPERMAKING MACHINERY

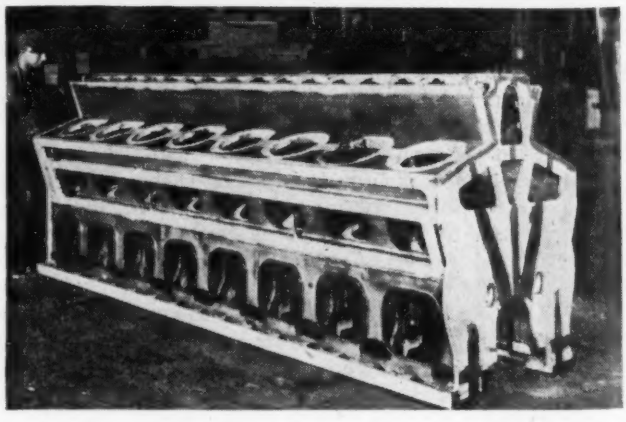


FIG. 19 CRANKCASE FRAME FOR 16-CYLINDER ENGINE

(This frame measures 11 ft 6 1/2 in. long by 2 ft 11 in. wide by 3 ft 7 1/4 in. high, and weighs 8800 lb.)

gressively, so that today a properly executed welded joint need not be regarded as a joint. A wide background of operating history substantiates this, for it is a recognized fundamental that a weldment when completed is not a number of separate components joined together, but a single homogeneous piece of steel.

The material, of course, must be weldable.

Many types of carbon steel and its alloys are readily welded, but some require special care, for instance, involving preheating.

Field welding, or structural repair, must be taken into account in the selection of steel. Perhaps design loads are based on physicals dependent on special heat-treatment. It is practically impossible so to treat the weldment in the field. Possibly the steel is not weldable at low temperature. Ordinarily these can be said to be considerations of little importance. They do apply in the selection of materials, for instance, in railroad service. In wrecks of minor nature, structural parts must be readily repaired either by rewelding or straightening.

This is an instance of the type of consideration in selecting materials for weldments; many others exist.

DESIGN CRITERIA ALSO FUNDAMENTAL

The second fundamental is that of design criteria. Naturally, the first of these is the type of service required of the structural part. The question of service requirements has been detailed in the eight basic reasons which we have illustrated. However, we have an interesting specific example which involves many implications with regard to service requirements as a basic criterion of design.

Several years ago a submarine was commissioned powered by Diesel engines, the frames of which were of welded steel, similar to the one shown in Fig. 19. This vessel completed roughly 10,000 hr on these engines in normal service, and from any standpoint the design of the engine frame had been proved satisfactory. Many hundreds of similar frames are in constant service today.

This particular submarine, however, has an interesting history from the engineering standpoint. It is understood that she was depth-charged many times, on two occasions so drastically that she was blown to the surface. Ultimately, the ship arrived on the West Coast with known fractures in the engine frames. Some repairs were executed at that time, and she was then brought to the East Coast under her own power for general overhauling.

The engines were dismantled completely, permitting detailed inspection, with the result that the engine frames were replaced, since many more fractures were discovered. To broaden the knowledge of design criteria, one of these fractured frames was returned to the fabricator for careful investigation. Location, type, and possible causes of the fractures were studied and all surface cracks and every inch of weld metal were examined carefully.

Exactly 126 separate fractures were found (undoubtedly all occurred sometime during combat or shortly thereafter, since they were noticed while the ship was still at sea) nevertheless the ship traveled several thousand miles, of necessity, following their discovery.

With reference to type and location, the cracks can be separated into a few categories. Some of them started at stress raisers due to machined contours, others at contours about openings. The profoundly interesting finding is that no failure started in the welds, or parent metal, of primary load-carrying members. Some of these members have rwo or more butt welds within their length. They are dynamically loaded in tension.

Some failures started in welds of secondary members, welds that were deliberately designed as simple fillets with internal fissures remaining. It was assumed that the stress in them was of a type or direction that would make such joints adequate, and they are adequate for normal operation.

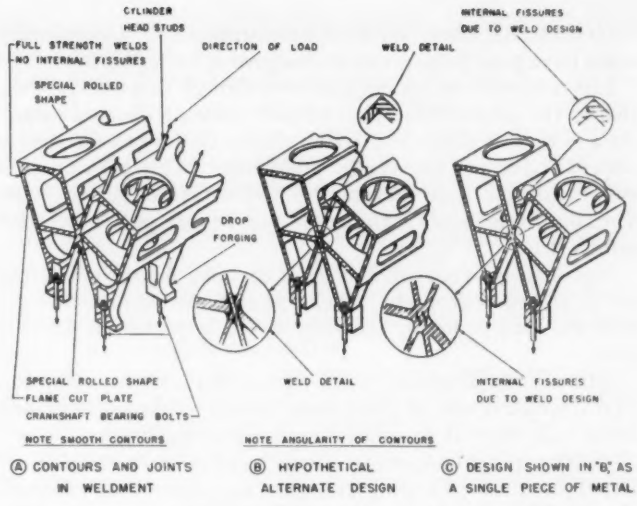

CYLINDER HEAD STUDS
FULL STRENGTH WELDS NO INTERNAL FISSURES
SPECIAL ROLLED SHAPE
DIRECTION OF LOAD
WELD DETAIL
INTERNAL FISSURES DUE TO WELD DESIGN
DROP FORGING
SPECIAL ROLLED SHAPE
FLAME CUT PLATE
CRANKSHAFT BEARING BOLTS
WELD DETAIL
INTERNAL FISSURES DUE TO WELD DESIGN
NOTE SMOOTH CONTOURS
NOTE ANGULARITY OF CONTOURS
Ⓐ CONTOURS AND JOINTS IN WELDMENT
Ⓑ HYPOTHETICAL ALTERNATE DESIGN
Ⓒ DESIGN SHOWN IN "B" AS A SINGLE PIECE OF METAL

FIG. 20 OUTLINES OF PRIMARY PORTION OF ENGINE FRAME SHOWN IN FIG. 19, ILLUSTRATING CONTOURS AS WELL AS POSITIONS AND TYPES OF WELDS

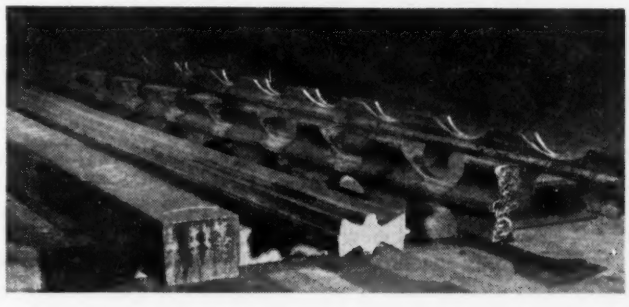


FIG. 21 PRODUCTION STAGES OF A WELDMENT COMPONENT
(At the left is initial billet; next, rough shape rolled from billet; third, further shaping by flame-cutting; fourth, shape, rough-machined to required dimensions.)

Certain conclusions can be drawn reasonably from this service history:

One is that design criteria for normal operation are much different from those required for battle action, if the structural parts of the power plant are expected to survive the hull or other parts of the vessel.

Another conclusion is that a welded machinery part most definitely can be designed to withstand unusual and indeterminate stresses. Those members and joints intended to carry maximum normal stress survived the drastic shocks perfectly.

Some of the fractures starting at other points crossed over welds in primary members which substantiates the conclusion that a welded joint can be so designed and executed that it need not be regarded as such. Otherwise it would be expected that the fracture would follow such a weld once it found it.

Finally, the frame was sufficiently rigid and structurally stable so that the severe shocks experienced still did not affect the operation of the engines. They brought the ship home!

METAL MUST BE DISPOSED PROPERLY

If properties of the material are to be utilized efficiently, the metal throughout the structure must be disposed properly. Where minimum weight or maximum rigidity are of primary importance, metal must be disposed so that design loads are carried with the most uniform stress throughout or with the maximum moment of inertia possible.

In Fig. 20 (*A*) is an outline of the primary portion of the engine frame just discussed. With regard to the disposition of metal, note the contours and the position of the welds. The frame could have been designed and built as shown at (*B*) and, as a

matter of fact, many are so designed initially. Undoubtedly some have gone into service so designed at such points.

It is reasonable to assume that even though they survive normal service, abnormal service of drastic nature will cause failure. At any rate, it is our conviction that such designs are utterly unpredictable and survive by good luck. This conviction is supported logically by the assumption illustrated in (*C*) where the same outline is shown as though it were a single piece of metal—which it is.

The internal voids shown exist to some degree unless the welds are made properly. Welds at such points in such a design are hard to make, and their X-ray inspection is difficult also.

If the section illustrated in (*C*) were cast, it is a safe assumption that it would not be accepted with the fissures shown, yet many times such internal voids are designed into weldments.

Another point concerning proper disposition of metal is external contour. Flowing contours are natural to castings, the necessity being imposed by foundry requirements. They are necessary for another reason, too, in the structures of the type which we are discussing, because they provide relatively even stress levels; either designed or unpredictable. This logically is an absolute requirement for minimum weight and maximum serviceability.

Such design criteria cost money and there seems to be a natural tendency to just "weld" and hope for the best. Service records, however, substantiate our convictions on this score.

What is the economic comparison between first cost and minimum weight or predictable serviceability if these two things are definitely required?

Fig. 21 shows the production stages of the component noted in the center of the left view in Fig. 20 (*A*).

On the left is the initial billet. Next we have the shape rolled from this billet. Following this, the part is further shaped to the desired contour by flame-cutting on a multiple-torch machine. Finally, the piece is rough-machined to required dimensions. Welding kerfs are provided in the same machining operation.

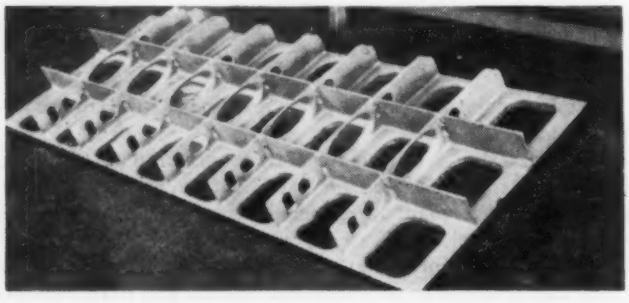


FIG. 22 TYPICAL SUBASSEMBLY, WITH WELDING COMPLETED AS SHOWN, ACCESSIBLE FROM THE STANDPOINT OF WELDING AND INSPECTION

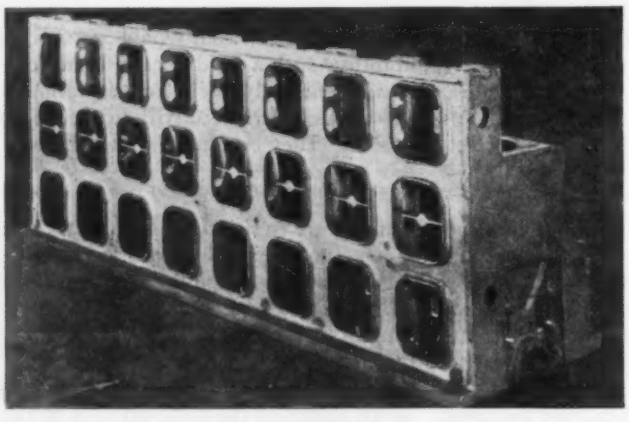


FIG. 23 FRAME FOR ENGINE, IN WHICH TYPICAL SIDE-PLATE ASSEMBLY, SHOWN IN FIG. 22, IS USED

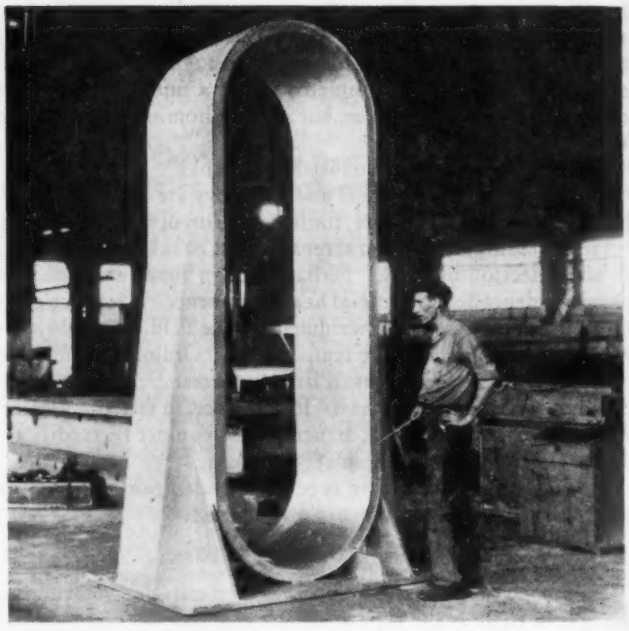


FIG. 24 WELDED STEEL FRAME FOR HYDRAULIC PRESS OF 2000 TONS CAPACITY

(The frame consists of two steel plates formed in U-shape and joined by butt welding.)

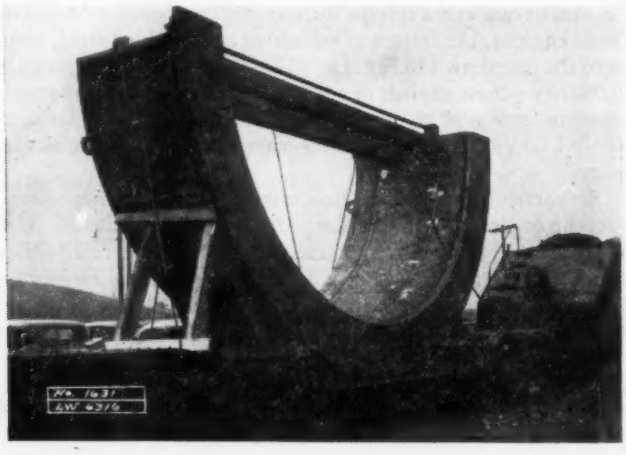


FIG. 25 ONE OF TWO HALVES WHICH WERE BOLTED TOGETHER TO FORM A COMPLETE THROAT RING FOR A TURBINE UNIT AT A LARGE DAM

(The throat ring measures 27 ft 6 1/2 in. OD by 23 ft 0.694 in. ID by 22 ft at top by 7 ft 11 5/8 in. high and weighs 66,960 lb.)

WELDING CONDITIONS AS A DESIGN CRITERION

Another typical criterion is the welding conditions imposed by the design. Full-strength welds must be accessible so that they can be executed properly. Too, they must be designed so that they can be inspected readily. The first question here for the designer is the quality of weld required.

Fig. 22 shows a typical subassembly as an example, with the welding completed as shown, accessible from the standpoint of both welding and inspection. Shrinkage and warpage have been eliminated as effects on the final assembly and the other portion of the final structure. This is due mainly to the freedom in design that two-dimensional plates allow for almost any conceivable size. Welding has been carried out under most accessible conditions. The work has been inspected and

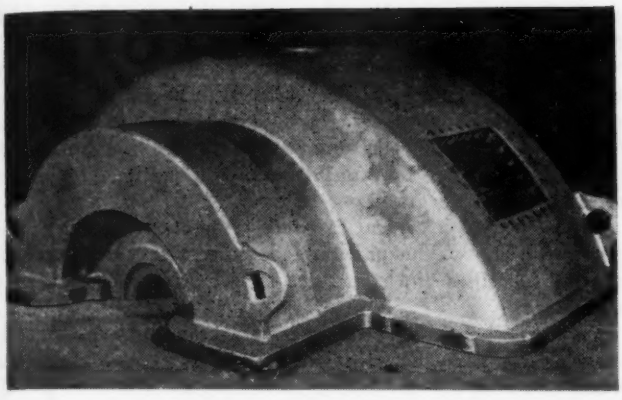


FIG. 26 HALF OF A FLANGED STEEL HEAD IS USED TO PROVIDE VERTICAL WALLS AND ROUNDED CORNERS OF MAIN PORTION OF THIS WELDMENT
(It is part of upper housing for a ship turbine.)

FIG. 27 COMPONENT PART OF REAR-AXLE HOUSING SHOWN IN FIG. 28

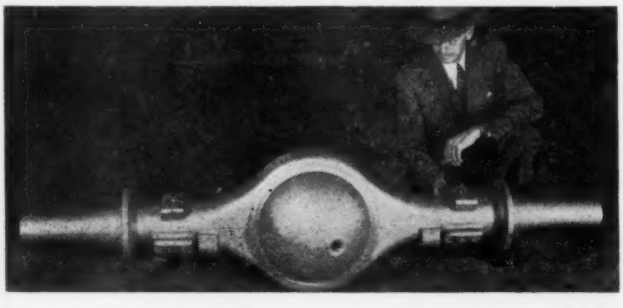


FIG. 28 REAR-AXLE HOUSING 6 FT 8 IN. OVER-ALL WEIGHING 250 LB, USING THE PART SHOWN IN FIG. 27

controlled separately from the standpoint of shrinkage or warpage.

Fig. 23 shows the subassembly, Fig. 22, in its final position with the joining welds between this subassembly and the remainder of the structure executed through the openings.

TRENDS IN TYPES OF COMPONENTS

Definite trends emerge in the type and form of components being used in weldments. These trends are established naturally by economy and inherent design freedom.

It is quite evident from the examples given that hot-rolled plate is the predominant component. Undoubtedly this is due mainly to the freedom in design that two-dimensional plates allow, for almost any conceivable size or shape can be designed using plate as the basic component.

Judicious use of other types of components in combination with plate provides added freedom and economy. The various methods of shaping or forming plate are utilized for the same reasons.

The most widely used plate component is, of course, the flame-cut shape.

Bent plates, typified by those shown in Fig. 24, are used to advantage in many applications. The stiffening side members of this hydraulic-press frame are of plate formed on the press brake. Their use in this typical instance reduces the welding required, provides initial stiffness or stability in the component, and adds to the appearance of the weldment.

The primary member of this frame is composed of two plates formed on the bending rolls and butt-welded.

The utilization of plate components formed on the bending roll is exemplified also by the huge weldment, Fig. 25, which is part of a hydroelectric installation.

Hot-flanged or "spun" heads often are used to advantage as components. In the weldment, shown in Fig. 26, one head is halved to provide the vertical walls and rounded corners of the main portion of this structure. Welding is simplified, and better appearance results. With the advent of quantity requirements, there is a trend toward the use of hot pressings or stampings, as shown in Fig. 27. This one is approximately 53 $\times$ 10 $\times$ 6 in. of $^{7}/_{16}$-in. thickness. Two such pressings form the major portion of the housing illustrated in Fig. 28.

Designs based on quantity production include to advantage drop-forged components. Those on the left in Fig. 29 are typical of the thousands which have been used in weldments. They provide freedom of shape and eminent predictability where necessary and forging-die cost becomes insignificant in such quantity applications. The forged and machined component on the right forms the hub of the large gear blank in Fig. 8.

Fig. 30 is an interesting specialized use of a drop-forged component, consisting of several small forgings which are flash-welded together. Design freedom in shaping for minimum weight and maximum predictability results.

Castings are utilized in a similar manner in Fig. 31. Eight

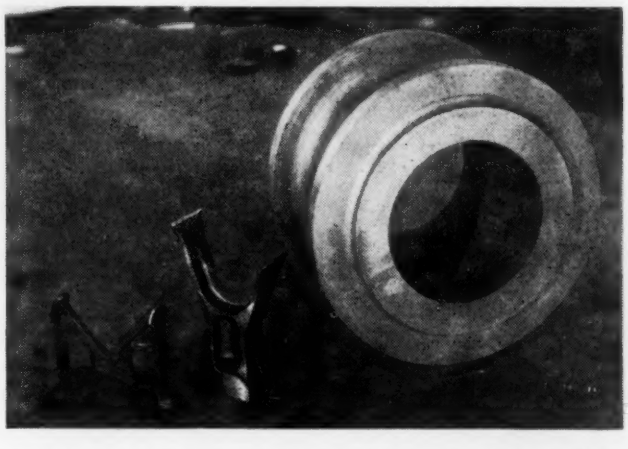


FIG. 29 DROP-FORGED COMPONENTS, TYPICAL OF THOUSANDS WHICH HAVE BEEN USED IN WELDMENTS

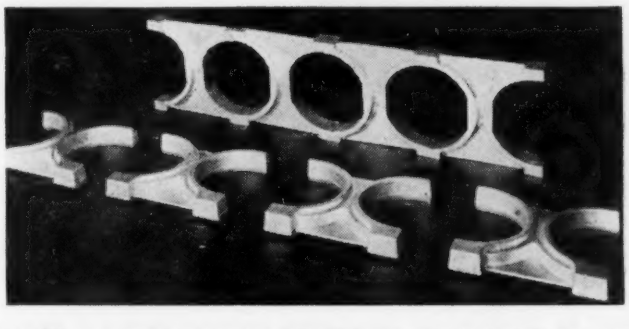


FIG. 30 DROP-FORGED SECTIONS WHICH WERE FLASH-WELDED AS SHOWN TO FORM A COMPONENT OF A WELDMENT

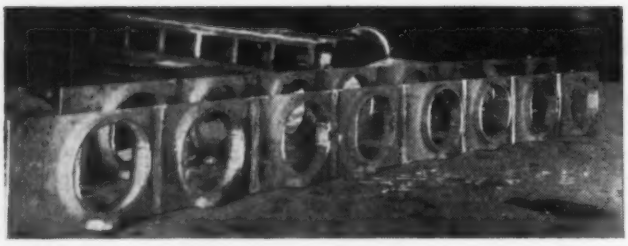


FIG. 31 EIGHT SMALL STEEL CASTINGS ARE FLASH-WELDED TO PROVIDE THIS COMPONENT

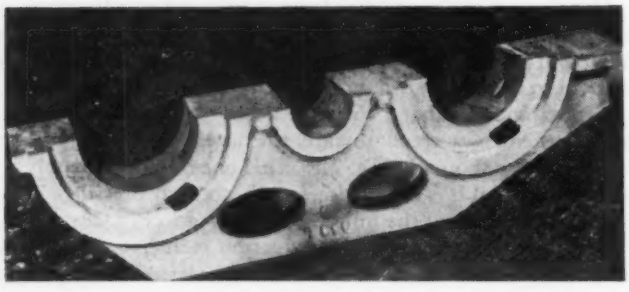


FIG. 32 COMPONENT OF MACHINERY WELDMENT
(Such components are used in weldments of such size or nature as to be prohibitive, or impossible, as one-piece steel castings or forgings.)

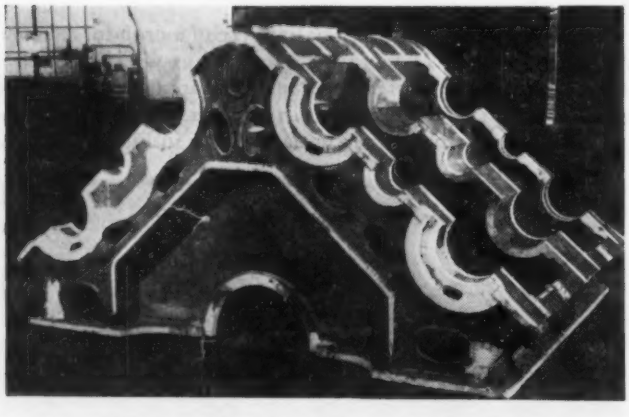


FIG. 33 WELDMENT IN WHICH CASTING SHOWN IN FIG. 32 IS USED

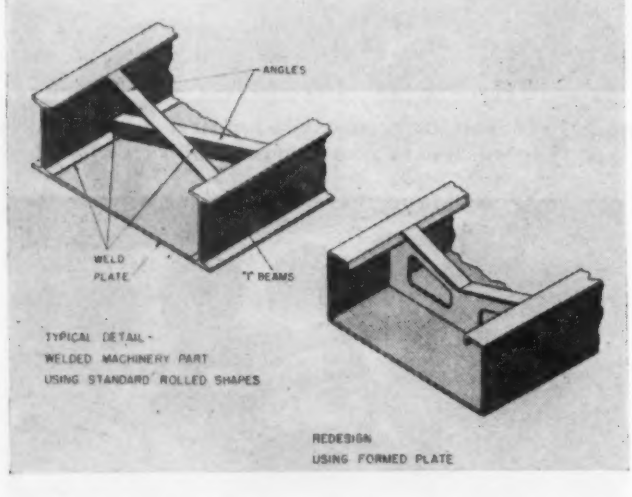


FIG. 34 ELEMENTARY COMPARISON SHOWING ORIGINAL DESIGN UTILIZING I-BEAMS AND ANGLES, ON LEFT, AND SIMPLIFIED REDESIGN ON RIGHT

small, hence more predictable, steel castings are flash-welded together to provide this component.

Hundreds of tons of steel castings, as shown in Fig. 32, are used as components in machinery weldments and this use has opened a completely new market for steel castings as well as forgings. Generally, such components are used in parts of such size or nature as to be prohibitive or impossible as one-piece steel castings or forgings.

Fig. 32 shows a typical cast-steel component. Clearly this portion of the weldment would be more costly in plate, but properly specified and controlled steel castings are eminently satisfactory.

Fig. 33 is the weldment in which the previously shown casting is used. Six such castings or larger ones are used in this one piece.

There is a tendency to utilize standard structural rolled shapes in machinery weldments although their value as components is questionable in many instances. This is logical when it is remembered that available rolled shapes were evolved for an utterly different purpose. Hence their use in machinery parts often seems a makeshift.

Fig. 34 is a typical elementary comparison. The original design, utilizing I-beams and angles, is shown on the left with the redesign adopted on the right. Welding is reduced, lateral stability is increased, and the appearance is improved. Also, abrupt projections are eliminated, fitting and welding are simplified, and the transverse member is more effective at equal weight.

It is possible that shape mills will evolve new sections as required tonnage develops, and if so, the shapes will be designed to suit this new function.

The author's company operates a small tonnage mill which provides rough shapes such as these shown in Fig. 35, solely for

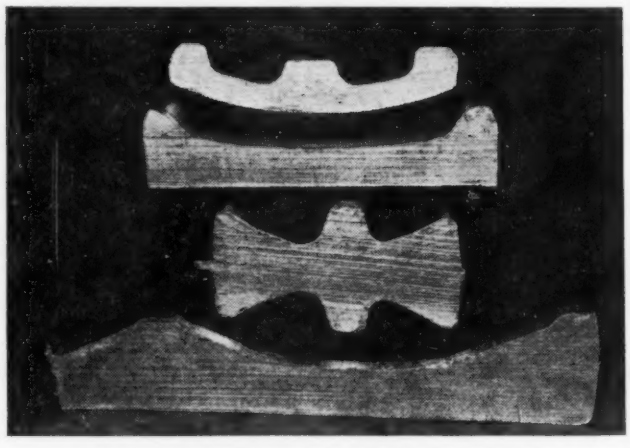


FIG. 35 ROUGH SHAPES SUCH AS THESE ARE ROLLED FOR WELDMENTS
(Added freedom results.)

weldments. Roll cost is low but this is essential to the relatively small tonnages required. As a result surface finish is not equal to that of the usual shape in quality but the product is well suited to its use.

This mill has provided us with added design freedom and gives us such components, which formerly were machined from solid slabs.

MACHINERY-PARTS WELDING SPECIFICATIONS NEED TO BE DEVELOPED

Finally, we have the important subject of specifications. No well-defined trend has as yet developed in the specification of welded machinery parts; at least, none that the author has observed, except that progress has been made in nomenclature.

(*Continued on page 129*)

REPLICA METHOD *for* EVALUATING *Finish of a* METAL SURFACE

By HARRY K. HERSCHMAN

METALLURGIST, NATIONAL BUREAU OF STANDARDS, UNITED STATES DEPARTMENT OF COMMERCE, WASHINGTON, D. C.

Introduction

DURING the past decade, great advances have been made in the art of finishing surfaces mechanically, especially of metal objects. In a large measure, this can be attributed to studies in which hitherto unknown correlations of mechanical and physical properties of metals, with the character of their surfaces, were revealed. Despite this progress and the development of means for closely controlling the type and degree of finish, the modes of specifying and designating them with particularity have not been developed sufficiently to be universally acceptable to industry. The importance of such specifications may be gleaned from the extensive study and discussion of this subject since 1930, by Sectional Committee (B46) for the standardization of classification and designation of surface quality (1),[1] sponsored by The American Society of Mechanical Engineers and the Society of Automotive Engineers under authorization of the American Standards Association. This subject has also constituted a major phase of a broad investigation of surface finish reported by the Institution of Production Engineers (2), (England).

Two essentials for the specification of a surface finish are (*a*) the qualitative factors, such as distribution and orientation of surface irregularities and defects, and (*b*) the quantitative aspects, which are concerned with the exact depths and spacings of surface irregularities, as well as with the trueness of the surface. Way (3) has described the principal qualitative and quantitative methods for studying surface finish. In addition, he has summarized their salient features, limitations, and disadvantages.

Any device for evaluating surface finish to be acceptable to industry must perform accurately and rapidly, be reasonable in cost, and yield reproducible results. Because of the widespread interest and importance of this subject, the National Bureau of Standards has investigated the application of nearly transparent surface replicas for evaluating surface finish. This study has resulted in the development of a method for evaluating the finish of a surface through the medium of a properly prepared replica of such surface. It is believed that this method offers considerable promise in connection with specifications and standards for surface finish.

Apparatus and Method of Procedure

This method of surface analysis is based upon a rapid and accurate procedure for preparing a nearly transparent facsimile of the surface to be evaluated. The fidelity of reproduction of minute surface characteristics in replicas, consisting of a thin film of a suitable plastic, is attested by the fact that such replicas are used in the study of metal microstructures at high magnifications with the electron microscope (4, 5).

The plastic replica of a surface may be produced by different means. In this study it was prepared by applying a suitable solvent to the metal surface, following which a strip of clear plastic film was pressed on. The solvent softened the side of the film adjacent to the surface being examined and permitted it to flow and conform under pressure to the minute surface irregularities. The film dried in about 1 min and then was stripped readily from the surface. This general procedure for producing replicas of surfaces was brought to the attention of the author by R. D. McDill (6).

In the present study, the solvent used was composed of 80 per cent toluene and 20 per cent acetone. The plastic was a preformed film of ethyl cellulose, 0.005 in. thick × 1.5 in. wide. In some experiments, an oil-soluble dye was added to the solvent to develop greater detail of the surface serrations (7). The dyes used were National "Nigrosene B" (black) and National "Oil Red O." The film was pressed on by rolling with a special roller of pliable rubber. Characteristic details of replicas produced in this manner are illustrated in Fig. 1.

Examination of these replicas showed, as may be expected, that the degree of transparency decreased with increased roughness of the original surface. However, of greater significance was the fact that the rougher the metal surface, the more pronounced became the variations in the geometry of the

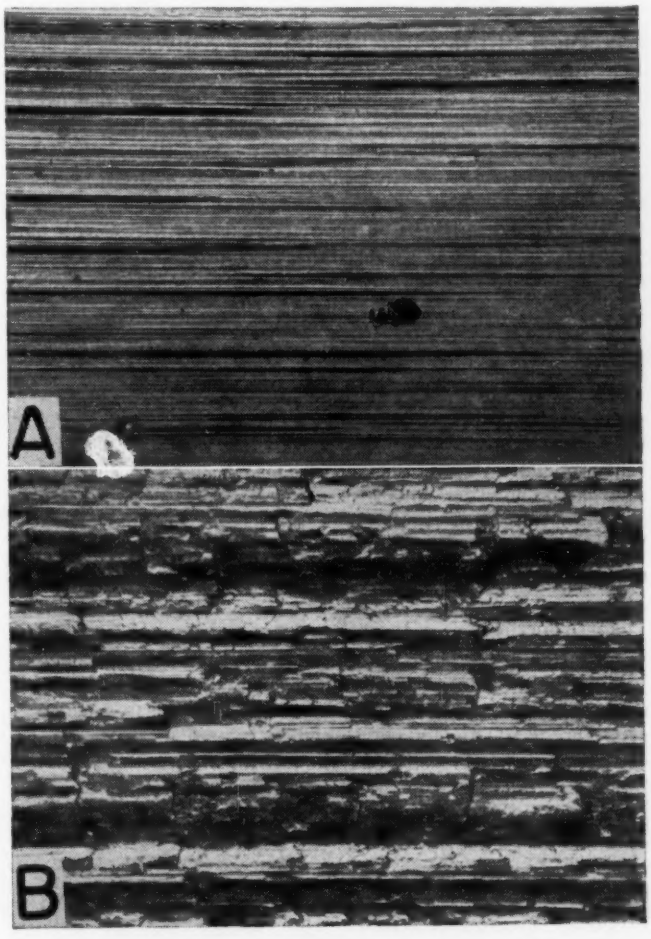
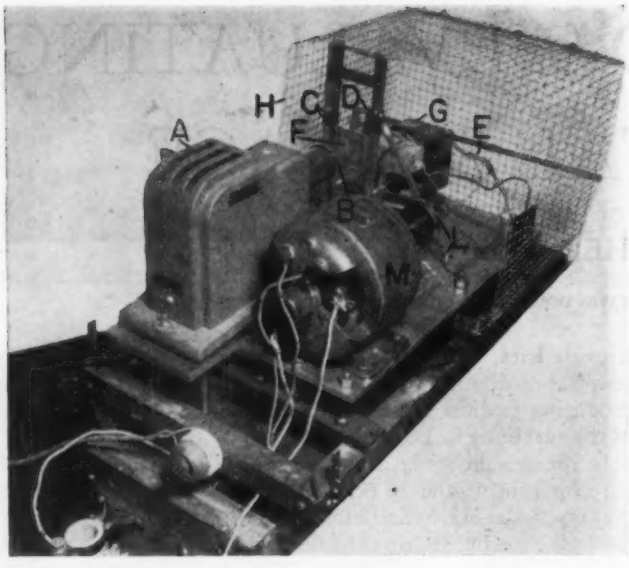


FIG. 1 MICROGRAPHS OBTAINED FROM PLASTIC REPLICAS

(*A*, Finely ground surface; and *B*, coarse-shapered surface, photographed with transmitted light; ×100.)

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.



A Light source
B Condensing lens
C Frame for holding replica of surface finish
D Photoelectric (caesium) cell
E 5-megohm resistance
F Replica
G 90-volt "B" battery
H Screen for shielding out stray currents
L Cam and lever for actuating frame *C*
M Motor for driving cam and lever *L*

FIG. 2 "REPLICA" SURFACE ANALYZER DEVELOPED AT THE NATIONAL BUREAU OF STANDARDS

reproduced pattern. This fact led to the development of an apparatus for evaluating surface roughness, based upon the degree of variation of the geometric characteristics in a nearly transparent replica.

The apparatus is illustrated in Fig. 2. Basically its operation consists in passing a restricted beam of light from light source *A* through an oscillating test replica *F;* thence onto a photoelectric cell *D*, thus causing a pulsating current from the 90-volt battery *G* to pass through a resistance *E* connected in series with cell *D*. The voltage drop across resistance *E* is measured with an alternating-current electric voltmeter, Fig. 3. The light striking the cell causes a photoemission of electrons from the cell cathode to the plate, thereby closing the circuit and permitting the current to flow through the system, which is diagrammatically illustrated in Fig. 3. If the intensity of the light striking the cell does not vary, a constant direct current will flow in the circuit, which will not register on the alternating-current voltmeter. However, the light transmitted through the oscillating replica is of variable intensity, because of differences in the geometric characteristics of the replica from area to area scanned by the beam, as illustrated in Fig. 4.

These fluctuations of intensity of the transmitted light cause a corresponding variation of electron transmission, which produces a pulsating voltage. Since resistance *E* is constant, the voltage drop is a measure of the current passing through resistance *E*. This current, which is related to the degree of variation of the intensity of light passing through the moving replica, increases as the variations of the geometric characteristics of the different areas of the replica become more pronounced, or in other words as the degree of roughness of the reproduced surface increases. It is by reason of this correlation that the roughness of a surface may be evaluated by the "replica" method described. The voltage readings may be calibrated in terms of profile "peak-to-valley" values of the surfaces, determined with the microscope on the original specimens, Fig. 7.

A diagrammatic sketch of the device, illustrating details of the electric circuit, is shown in Fig. 3. Since the magnitude of the current passing through the circuit is very small and the electronic voltmeter is extremely sensitive, precautions were taken to shield out extraneous currents. This was accomplished by enclosing the apparatus within the properly grounded wire screen *H*, illustrated in Fig. 2.

The area of the replica covered by the scanning beam for a single setting is controlled by two factors, (*a*) the condensing lens *B* (Fig. 2), and (*b*) the total length of travel of the replica *F* (Fig. 2). The lens limits the width of the beam at the area of contact with the replica. The length of the area covered by this image during a test is regulated by the setting of the eccentric and lever *L* (Fig. 2). The shorter the focal length of lens *B*, the narrower the image. A 16-mm lens, found most suitable for the tests reported in this paper, produced a rectangular image about 0.2 in. wide × 0.01 in. high in one case, and 0.2 in. wide × 0.004 in. high in the second case (Fig. 7). The eccentric and lever were adjusted to permit a $^3/_4$-in. length of travel of the replica. Thus the dimensions of the area covered for a single test setting were about $^3/_{16}$ in. × $^3/_4$ in.

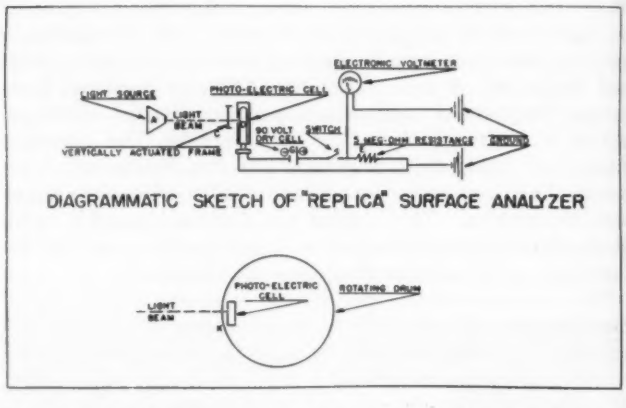


FIG. 3 DIAGRAM SHOWING DETAILS OF ELECTRIC CIRCUIT OF "REPLICA" SURFACE ANALYZER DEVELOPED AT THE NATIONAL BUREAU OF STANDARDS

(Rotating drum *K* may be substituted for vertically actuated frame *C* to accommodate extra-long replicas.)

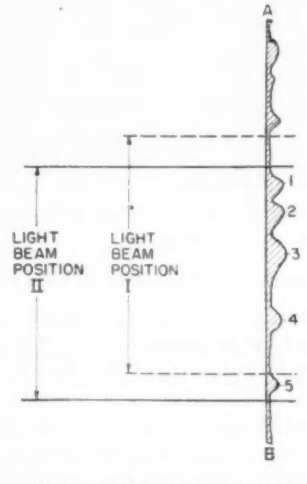
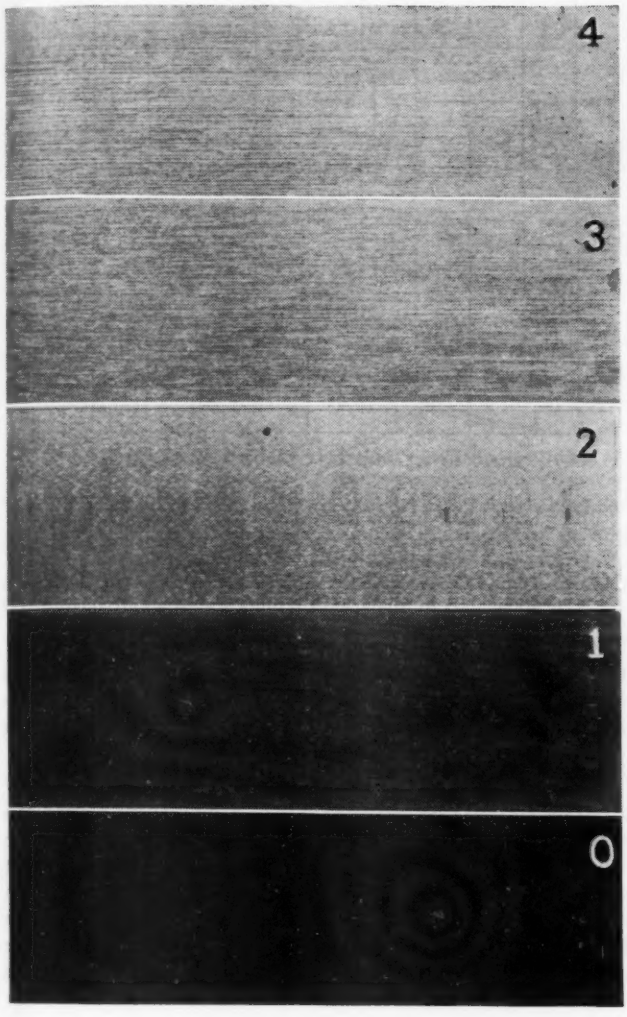


FIG. 4 DIAGRAMMATIC SKETCH ILLUSTRATING AN EXAMPLE OF MANNER IN WHICH CHANGES OCCUR IN INTENSITY OF LIGHT TRANSMITTED THROUGH A MOVING REPLICA

(*A–B* represents a section of a replica of a surface finish showing the profile contour. The number and nature of irregularities included within limits of beam in positions I [sections 1, 2, 3, and 4], and II [sections 1, 2, 3, 4, and 5], respectively, differ, and therefore the transmitted light reaching a fixed area, such as the slit of a photoelectric cell, will differ in the two cases.)



Specimen number	Type of finish	Average peak-to-valley profile depth (microscopic section), in. $\times 10^{-6}$ (a)	Average profile evaluations (rms) in. $\times 10^{-6}$	Replica - surface-analyzer evaluation diaphragm B (b) mv $\times 10^{-1}$
0	Polished	11	1.5	8
1	Lapped	28	4	16
2	Fine-ground	46	7–11	25
3	Fine-shapered	320	65–70	54
4	Coarse-shapered	720	150–170	92

(a) Each value is the average of 50 to 60 determinations made on 3 sections of each specimen.

(b) Diaphragm B consisted of an alignment of 10 holes, each about 0.05 in. diameter, with centers spaced approximately 0.12 in. apart.

FIG. 5 CHARACTERISTIC APPEARANCES OF SURFACES OF TEST SPECIMENS, PHOTOGRAPHED BY REFLECTED LIGHT DIRECTLY FROM SPECIMENS; × 1

In cases which require the analysis of exceptionally long surfaces, the rotating frame K (Fig. 3) could be used for supporting the replica.

Two factors which influence the sensitivity of the test are the dimensions of the slit in the shield over the photoelectric cell D (Fig. 3), and those of the diaphragm (not illustrated) inserted between light source A and lens B (Fig. 2) to restrict the vertical dimension (height) of the beam of light projected through lens B. The optimum height of the light beam and of the slit in the cell shield is influenced by several factors such as intensity of light source, the type of diaphragm used, etc. In the present study, the slit in the shield of the photocell was approximately 0.25 in. long × 0.03 in. wide. The diaphragms used are illustrated in Fig. 7. The height of the beam as revealed by the image formed on the test replica was about 0.01 in.

Although the rate of oscillating the test replica influenced the current flow and therefore the reading on the meter, the rate was not critical. Thus the maximum reading for each of the tests made was obtained within the limits of 200 to 300 oscillations per min.

EXPERIMENTAL OBSERVATIONS AND DISCUSSION

In order to ascertain the practicability of the replica method for surface analysis, five specimens, shown in Fig. 5, which differed among themselves significantly in their surface roughness, were prepared. The characteristic contour of the profile for each specimen is shown in Fig. 6. Surface facsimilies made from each of these specimens, using both clear and dyed solvents, were submitted to test on the "replica" surface analyzer, Fig. 2.

Replicas containing dye have the advantage of revealing somewhat greater details of the metal surfaces than did the color-free replicas. However, the results which were obtained on the surface analyzer from duplicate replicas without dye additions of the same surface were distinctly more reproducible.

Typical results obtained on duplicate replicas, prepared without the use of dye, are shown in Table 1. Because of this greater reproducibility, the replica surface evaluations given in this paper are confined to those obtained with facsimiles prepared without dye. Nevertheless, the use of dyes for this purpose appears to have merit and warrants further study.

TABLE 1 RESULTS ON DUPLICATE REPLICAS

Type finish	Replica number	Reading on replica analyzer millivolts $\times 10^{-1}$
Moderately coarse-shapered finish	1A	63
	2A	62
	3A	65
Finely ground finish	1	9.6
	2	9.8
	3	10.0

The tests of the replica surface analyzer were made with two types of diaphragms for restricting the beam of light, Fig. 3. One (A in Fig. 7) was of the conventional slit type, the slit opening being 0.02 in. wide. The openings in the other diaphragm (B in Fig. 7) consisted of ten aligned holes, each about 0.05 in. diam, with centers spaced about 0.12 in. apart.

Fig. 7 (curve 2) shows the correlation of the average profile (peak-to-valley) depth of the surface serrations, expressed in microinches, with the values of surface finish determined by the replica method, expressed in millivolts. Each profile value determined with the microscope and plotted in curve 2 is the average of 50 to 60 determinations made at different positions on three sections of a specimen. Curves 1 and 3 show the relation of the replica surface evaluations for the five test specimens (Fig. 5), to the root-mean-square values of the surfaces of these specimens, as determined by the profilometer method. Curves 1 and 3 show that the rate of change of the values secured on the replica surface analyzer for the same differences in surface roughness was greater with diaphragm B than with A.

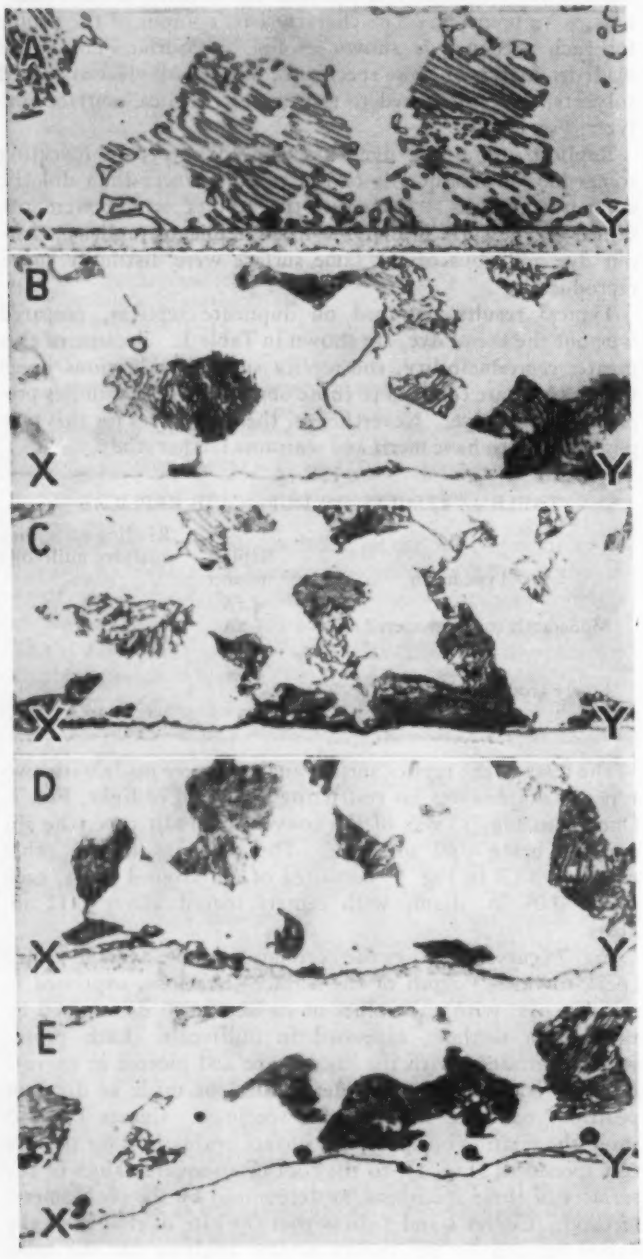
The curves in Fig. 7 indicate that the replica method of surface analysis is especially sensitive to small changes in surface roughness for the finer grades of finish. It is within this range that many of the conventional means for evaluating surface finish are not sufficiently sensitive.

The results reported should be considered as being strictly applicable to surface markings which are approximately unidirectional. Further work is planned to ascertain the effect of

orientation of surface markings on the evaluation of surface finish by the replica method.

Although the apparatus shown in Fig. 2 is relatively crude, it yielded very promising results. Even more promising results appear probable with the incorporation of certain other known types of slits, light sources, and means for scanning the film with the light beam. None of these was immediately available for the present study. The development of a suitable technique for using dyes in preparing these replicas may aid in further increasing the sensitivity of this method of surface analysis.

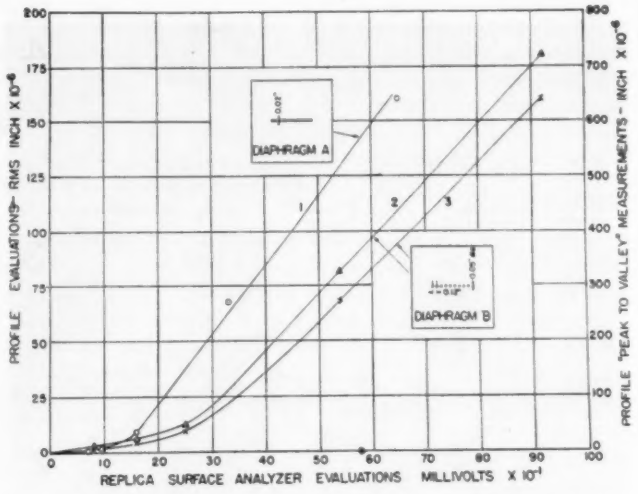
Some of the salient features of the replica method of surface analysis are (*a*) easy maintenance of a permanent record of a surface finish; (*b*) rapid average evaluation of a considerable length and width of surface at one setting; (*c*) simplicity of operation; (*d*) absence of the personal factor; (*e*) preservation of a surface, even for soft materials such as lead or tin-base bearing metals; and (*f*) availability of the method, since the replica may be prepared in one locality and transported to the location of the analyzer. This procedure might also prove useful in evaluating surfaces not readily accessible with present available means for surface analysis. There are indications that the method described also may be applicable for evaluating corrosion-pitting of metals.



A Polished surface
B Lapped surface
C Fine-ground surface
D Fine-shapered surface
E Coarse-shapered surface

FIG. 6 MICROGRAPHS OF SECTIONS OF TEST SPECIMEN, SHOWING CONTOUR OF PROFILE INDICATED BY TRACE X-Y, OF SURFACE OF EACH

(The edges were preserved by electroplating with about 0.0002 in. copper and about 0.002 in. nickel. Etched with 4 per cent picric-acid solution [in alcohol]; ×1500.)



Curve 1 Replica versus profile evaluation [rms], approximately 0.02-in-wide slit diaphragm used on "replica" surface analyzer.
Curve 2 Replica versus profile "peak-to-valley" measurements, determined with microscope.
Curve 3 Same as 1, except diaphragm had alignment of 10 holes, each about 0.05 in. diam with centers spaced approximately 0.12 in. apart.

FIG. 7 CURVES SHOWING RELATIONSHIP OF REPLICA SURFACE ANALYZER EVALUATIONS TO PROFILE PEAK-TO-VALLEY MEASUREMENTS, DETERMINED WITH THE MICROSCOPE, AND PROFILE EVALUATIONS EXPRESSED AS ROOT-MEAN-SQUARE VALUES

SUMMARY

A new method for evaluating surface roughness is described which involves the use of rapidly produced plastic replicas of variable transparency. Evaluations of surface finish made by this method on five specimens which differed significantly in degrees of finish were correlated with profile values of these surfaces determined by (*a*) the profilometer method (as root-mean-square values), and (*b*) the microscope on cross sections (peak-to-valley values). These data show that this replica method is especially sensitive for the evaluation of surfaces having high degrees of finish.

BIBLIOGRAPHY

1 Abstract of the Proposed American Standard, Publication No. B46, A.S.M.E., 1940.

2 "Surface Finish," by G. Schlesinger, Institution of Production Engineers, 1942 (reprinted by the A.S.M.E.).

3 "Description and Observation of Metal Surfaces," by S. Way, Proceedings of the Special Summer Conferences on Friction and Surface Finish, Massachusetts Institute of Technology, 1940, p. 44.

4 "Surface Studies With the Electron Microscope," by V. K. Zworykin and E. G. Ramberg, *Journal of Applied Physics*, vol. 12, 1941, p. 692.

5 "Surface Replicas for Use in the Electron Microscope," by V. J. Schaefer and D. Harker, *Journal of Applied Physics*, vol. 13, 1942, p. 427.

6 Private correspondence, June 13, 1943.

7 "Surface Replicas Containing Dye for Use in the Light Microscope," by V. J. Schaefer, *Metal Progress*, vol. 44, 1943, p. 72.

Some Engineering Properties of NICKEL *and* HIGH-NICKEL ALLOYS

By B. B. BETTY[1] AND W. A. MUDGE[2]

INTRODUCTION

THE industrial importance of nickel is greater than is suggested by its ninth-place ranking in the world's consumption of metals. The pure metal is invaluable for catalysts, hot cathodes in radio tubes, storage batteries, chemical processing equipment, and protective decorative purposes. As an alloying element, nickel enhances the useful characteristics of many times its own weight of steels and nonferrous alloys. Nearly 2300 compositions that contain one or more per cent are known and used (1).[3] The immediate restriction of the industrial use of nickel because of its indispensability for military purposes evidenced its strategic value.

The purpose of this article is to summarize the principal properties of approximately a score of important wrought and cast nickel materials which contain more than 50 per cent of nickel and which have been used extensively for power equipment, petroleum, laundry, food service, household equipment, pickling, roofing, and paper and pulp industries because of their excellent strength and corrosion-resisting characteristics. Some approved and economical methods for the construction of special equipment are described briefly. References, where detailed information is available, have been added.

MATERIALS

The materials are classified in six groups on the basis of chemical composition. Seven of the alloys[4] can be age-hardened by suitable thermal treatment; the others have a solid-solution structure and can be hardened only by cold-working.

1 Nickel: 99.4 to 95.2 per cent nickel and a maximum of 4.5 per cent manganese.

2 Nickel-copper: Approximately two-thirds nickel and one-third copper.

3 Nickel-silicon: Nickel 85 and silicon 10 per cent (cast only).

4 Nickel-chromium-iron: Nickel 78.5 to 60, chromium 13 to 18, and iron 6 to 24 per cent.

5 Nickel-molybdenum-iron: Nickel 60 to 53, molybdenum 18 to 32, and iron 6 to 22 per cent.

6 Nickel-chromium-molybdenum-iron: Nickel 60 to 51, chromium 17 to 22, molybdenum 5 to 19, and iron 6 to 8 per cent.

Nominal chemical compositions are given in Table 1. Available forms and mechanical properties of the wrought materials are summarized in Table 2, and similar data for the cast materials are included in Table 3. The effect of stress equalizing upon a cold-drawn Monel rod is shown in Fig. 1.

The materials have good strength and toughness and high ratios of strength to ductility in all conditions of mechanical and thermal treatments.

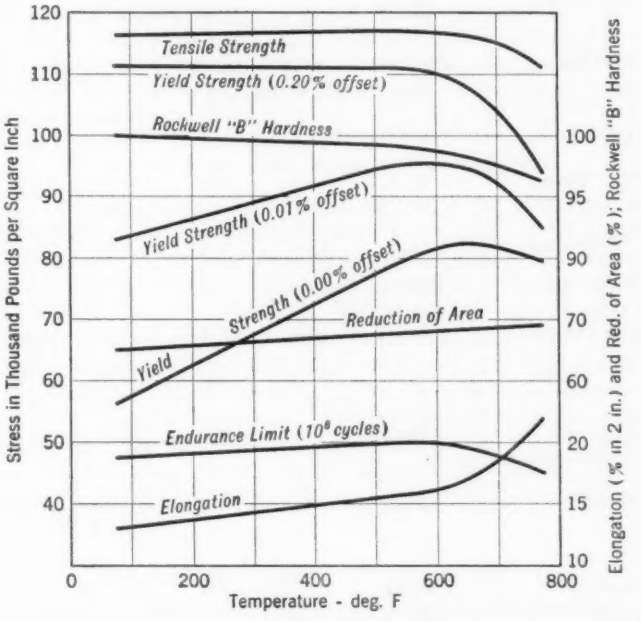


FIG. 1 EFFECT OF A 3-HR STRESS-EQUALIZING ANNEAL UPON THE MECHANICAL PROPERTIES OF A $^1/_2$-IN. COLD-DRAWN MONEL ROD

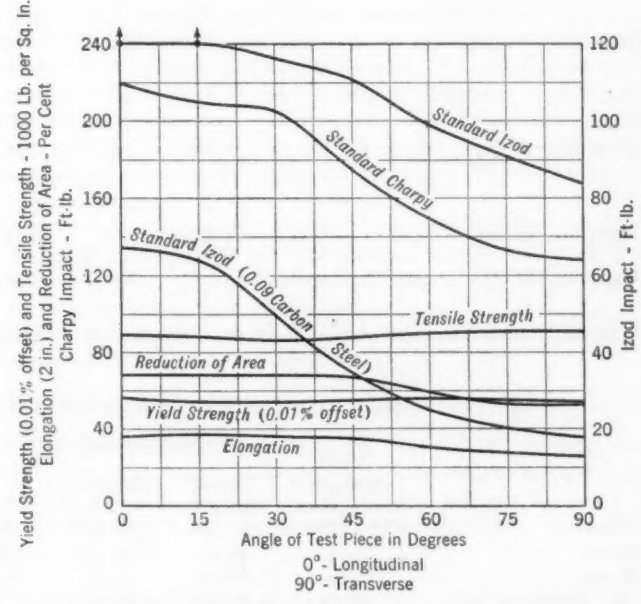


FIG. 2 DIRECTIONAL TENSILE AND IMPACT PROPERTIES OF A LARGE HIGH-STRENGTH MONEL FORGING

DIRECTIONAL TENSILE PROPERTIES OF FORGED MONEL

Directional tensile and impact properties determined[5] in a

[1] Betty Machine Co., Nashville, Tenn.; formerly Research Test Engineer, Huntington Works, The International Nickel Co., Inc., Huntington, W. Va. Jun. A.S.M.E.

[2] Assistant Director of Technical Service on Mill Products, Development and Research Division, The International Nickel Co., Inc., New York, N. Y.

[3] Numbers in parentheses refer to Bibliography at end ofpaper.

[4] "Z" Nickel, "K" Monel, "KR" Monel, and "S" Monel (trade marks of The International Nickel Co., Inc.), and "Hastelloy" A, "Hastelloy" B, and "Hastelloy" C (trade marks of Haynes Stellite Co.).

Contributed by the Metals Engineering Division and presented at the Annual Meeting, New York, N. Y., Nov. 27–Dec. 1, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[5] Standard A.S.T.M. specimens used.

TABLE 1 NOMINAL CHEMICAL COMPOSITION AND USES

Material	Nickel,[a] per cent	Copper, per cent	Iron, per cent	Manganese, per cent	Silicon, per cent	Chromium, per cent	Molybdenum, per cent	Carbon, per cent	Other elements, per cent	Uses
Nickel	99.4	0.1	0.15	0.2	0.05	...	...	0.1	...	Strength; resistance to corrosion and oxidation.
"L" Nickel	99.4	0.1	0.15	0.2	0.05	...	...	0.02[b]	...	Severe cold-working; containers for fused oxidizing salts; laboratory crucibles and combustion boats.
"Z" Nickel	98.0	...	...	...	...	...	...	...	...	Age-hardenable; high strength; springs.
"D" Nickel	95.2	0.05	0.15	4.5	0.05	...	...	0.1	...	Resistance to sulphidizing atmospheres; spark plugs.
Monel	67.0	30.0	1.4	1.0	0.1	...	...	0.15	...	Strength; resistance to corrosion.
"R" Monel	67.0	30.0	1.7	1.1	0.05	...	...	0.1	0.035 Sulphur	Free-machining.
"K" Monel	66.0	29.0	0.9	0.85	1.0	...	...	0.15	2.75 Aluminum	Age-hardenable; nonmagnetic; high strength; springs.
"KR" Monel	66.0	29.0	0.9	0.85	1.0	...	...	0.3	2.75 Aluminum	Age-hardenable; free-machining.
"H" Monel	65.0	29.5	1.5	0.9	3.0	...	...	0.3	...	High hardness.
"S" Monel	63.0	30.0	2.0	0.9	4.0	...	...	0.1	...	Age-hardenable; resistance to galling and erosion.
80 Nickel–20 chromium (22)	Bal.	...	0.5	0.2–2.0[c]	1.25	20.0	...	0.1	...	Resistance to oxidation; electrical heating units.
Inconel	78.5	0.2	6.5	0.25	0.25	14.0	...	0.08	...	Strength; resistance to corrosion and oxidation; springs; heat-treating equipment.
60 Nickel–15 chromium (22)	62–54	...	Bal.	0.1–1.0	1.0–1.5	12–16	...	0.06–1.0	...	Strength; resistance to oxidation; heat-treating equipment.
Illium G (23)	58.0	6.0	6.0	1.25	0.65	22.0	6.0	0.02	...	Strength; resistance to corrosion in nitric and in sulphuric acids.
Hastelloy "A" (24)	57.0	...	20.0	2.0	1.0	...	20.0	0.15	...	Age-hardenable; strength; resistance to corrosion in hydrochloric and in sulphuric acids.
Hastelloy "B" (24)	62.0	...	6.0	1.0	1.0	...	30.0	0.15	...	Age-hardenable; resistance to corrosion in boiling hydrochloric acid and in wet hydrogen-chloride gas.
Hastelloy "C" (24)	55.0	...	6.0	1.0	1.0	15.0	17.0	0.15	5.0 Tungsten	Age-hardenable; resistance to corrosion in strong oxidizing acids.
Hastelloy "D" (24)	85.0	3.0	...	1.0	10.0	...	...	...	1.0 Aluminum	Resistance to corrosion in sulphuric acid.

NOTES: [a] Includes a small amount of cobalt. [b] Maximum. [c] Depending upon use.

TABLE 3 MECHANICAL PROPERTIES AND PHYSICAL CONSTANTS OF CAST MATERIALS

	Mechanical properties					Physical constants			
Material	Yield strength, 0.2% offset, 10^{-3} psi	Tensile strength, 10^{-3} psi	Elongation in 2 in., per cent	Hardness Brinell	Izod impact strength, ft-lb	Specific gravity	Melting point, F	Thermal conductivity, Btu/sq ft/hr/F/in.	Modulus of elasticity, 10^{-6} psi
Nickel	20–30	45–60	30–15	80–125	90–75	8.34	2540–2600	410	21.5
Monel	32.5–40	65–90	45–25	125–150	80–65	8.63	2400–2450	180	18.5
"H" Monel	45–75	90–115	20–10	175–250	45–35	8.48	2350–2400	180	20.0
"S" Monel	80–115	110–145	4–1	275–375	9–1	8.36	2300–2350	180	21.0
Inconel	30–45	70–95	30–10	160–190	85–70	8.3	2500–2550	...	22.7
60 Nickel–15 chromium	40–60	60–70	5–2	170–210	...	8.3–8.	2450–2550	95–100	30–31
Hastelloy "A"	43–45	69–78	12–8	155–200	35–25	8.8	2370–2425	116	27.0
Hastelloy "B"	55–57	75–82	9–6	190–230	16–11	9.2	2410–2460	78	30.8
Hastelloy "C"	45–48	72–80	15–10	175–215	14–9	8.9	320–2380	87	28.5
Hastelloy "D"	36–41	36–41	0	55–55[a]	...	7.8	030–2050	145	28.9
Illium G	50–63	60–73	9.5–4	160–210	...	8.31	37	...	...

NOTE: [a] Rockwell C.

TABLE 2 MECHANICAL PROPERTIES AND PHYSICAL CONSTANTS OF WROUGHT MATERIALS

Material	Available forms[a]	Mechanical properties: Yield strength, 0.2% offset, 10^{-3} psi	Tensile strength, 10^{-3} psi	Elongation in 2 in., per cent	Reduction of area, per cent	Hardness Brinell	Charpy impact strength, ft-lb	Endurance limit, 10^{8} cycles, 10^{-3} psi	Physical constants: Specific gravity	Melting point, F	Thermal conductivity, Btu/sq ft/hr/F/in.	Modulus of elasticity, 10^{-6} psi	Thermal expansion coefficient, (32–212 F) 10^{6} in./in./F
Nickel	ABCDEF	15–155	60–165	50–2	75–50	90–230	222–195	23–36	8.89	2615–2635	420	30	7.2
"L" Nickel	ACDE	15–25	55–75	55–35	75–50	25–55[b]	.....	...	8.89	2615–2635	420	30	7.2
"Z" Nickel	ACE	30–150	90–250	50–2	65–15	140–380	240–36[c]	52–59	8.75	2615–2635	420	30	7.2
"D" Nickel	ACE	25–125	75–140	50–2	75–60	110–230	.....	...	8.78	2600	335	30	7.4
Monel	ABCDEF	25–160	70–170	50–2	75–50	110–250	220–150	30–50	8.84	2370–2460	180	26	7.8
"R" Monel	AC	25–130	70–140	50–4	70–50	110–230	196–140	28–41	8.84	2370–2460	180	26	7.8
"K" Monel	ABCEF	40–175	90–200	45–2	70–25	140–320	170–42[c]	41–59	8.47	2400–2460	130	26	7.8
"KR" Monel	AC	40–175	90–200	45–2	70–25	140–320	.....	...	8.47	2400–2460	130	26	7.8
80 Nickel–20 chromium	ABCDEF	50–190	100–200	35–0.5	70–40	170–300	.....	...	8.42	2550	104	..	7.3
Inconel	ABCDEF	25–175	80–185	50–2	70–40	120–290	230–151	41–60	8.51	2540–2600	104	31	6.4
60 Nickel–15 chromium	ABCDEF	40–160	80–175	35–0.5	70–40	180–235	.....	...	8.2–8.6	2450–2550	95–100	31	7.6
Hastelloy "A"	ABCDEF	47–52	110–120	48–40	54–40	200–215	77–62[d]	...	8.80	2370–2425	116	27	6.1
Hastelloy "B"	ABCDEF	60–65	130–140	45–40	45–40	210–235	78–68[d]	...	9.24	2410–2460	78.5	30.8	5.6
Hastelloy "C"	DEF	55–65	115–128	50–25	...	160–210	40–34[d]	...	8.94	2320–2380	87	28.5	6.3

NOTES: [a] A—Rods and bars over 1/2 in. diam
B—Forgings
C—Wire, 1/2 in. diam max
D—Sheet
E—Strip
F—Tubing

[b] Rockwell B.
[c] Specimens fractured completely.
[d] Izod.

forged Monel rod, 9 5/8 in. diameter × 22 ft long × 6000 lb, are shown in Fig. 2.

The curve shows practically equal strength factors in longitudinal, midway, and transverse sections. Ductility is less, but ample, in the transverse direction.

COMPRESSIVE PROPERTIES

Table 4 summarizes the compressive properties[6] of six high-nickel materials (2). Compressive loads which exceeded the yield strength, 0.2 per cent offset, gave progressive plastic deformation up to the capacity of the testing machine (175,000 psi of original area). The test specimens "barreled out" to finish with average increases of 20 per cent in area and decreases of 15 per cent in length. Stress-strain curves showed reliably true elastic properties and no gradual deviations from the original.

IMPACT PROPERTIES—TENSION AND TORSION

These data were determined along with the compressive properties (2). The tension impact tests gave clean fractures in every case and permitted accurate measurements of elongation and reduction of area. In torsion impact, fractures occurred only with the age-hardened "K" Monel and "Z" nickel specimens; attempts to produce fractures in these alloys and in the others in the hot-rolled and cold-drawn conditions, by reducing the minimum area 75 per cent, were not successful because of their extreme toughness. Values ranged from 75 to 180 ft-lb depending upon the condition of the alloy. "K" Monel was outstanding, having values of 180 ft-lb with a tensile strength of 99,900 psi and 143 ft-lb with a tensile strength of 157,650 psi.

MECHANICAL PROPERTIES AT ELEVATED TEMPERATURES

Nickel can contribute increased strength and resistance to oxidation at elevated temperatures to both nonferrous and ferrous alloys and is especially useful in the latter because it produces an austenitic structure which is associated with high creep strength, particularly at relatively high temperatures. Resistance to oxidation is measured in terms of freedom from scaling and intercrystalline attack. Mechanical properties used for evaluating the limiting temperatures of materials for useful service are (1) short-time, high-temperature tensile properties, (2) hot-bend tests, (3) creep strength, (4) high-temperature impact strength, (5) endurance limit at elevated temperatures, and (6) hot hardness.

If the cross section of a material is reduced rapidly by oxidation and scaling, high strength alone is of little value; if the material cannot support the required load nor withstand fatigue, freedom from scaling is inadequate.

Table 5 summarizes creep,[7] endurance limit[8] and Charpy impact[9] data for annealed Inconel (3).

MECHANICAL PROPERTIES AT SUBZERO TEMPERATURES

A recent summary (4) of nickel, Monel, "K" Monel, and Inconel shows that the strength factors increase as the temperature is lowered; elongation increases to a lesser extent, and there is no appreciable change in reduction of area. Data are given in Table 6.

[6] Determined in triplicate, according to the A.S.T.M. standard procedure, from single, typical melts.

[7] Conducted in conformance with the A.S.T.M. Tentative Standard E 22-38T, developed by the A.S.T.M.-A.S.M.E. Joint Committee on the Effect of Temperature on the Properties of Metals.

[8] Tests made at 3550 reversals of stress per minute, using a 1/2-in-diameter × 16-in-long specimen with a reduced section in the high-temperature zone.

[9] A.S.T.M. Standard Charpy U-notch specimen used. Specimens were heated properly to the desired temperature, withdrawn quickly from the furnace, and placed in position for impact by the striking hammer.

TABLE 4 COMPRESSIVE PROPERTIES

Material	Condition	Compression: Yield strength,[a] 0.01% offset, 10^{-3} psi	Compression: Yield strength, 0.20% offset, 10^{-3} psi	Tension: Yield strength,[a] 0.01% offset, 10^{-3} psi	Tension: Yield strength, 0.20% offset, 10^{-3} psi	Tensile strength, 10^{-3} psi	Elongation in 2 in., per cent	Reduction of area, per cent	Hardness Brinell, 3000 kg
Monel	Hot-rolled	33	38	37	41	84	39.5	67.5	145
	Cold-drawn[b]	58	81	75	87	97	27.0	66.5	200
	Cold-drawn, annealed[c]	19	28	28	33	78	44.0	66.0	125
"R" Monel	Hot-rolled	26	34	33	36	76	39.5	69.0	120
	Cold-drawn[b]	51	66	62	74	83	28.0	66.5	180
	Cold-drawn, annealed[c]	23	26	25	28	73	44.5	70.0	115
"K" Monel	Hot-rolled	34	40	41	47	100	42.5	63.5	165
	Hot-rolled, age-hardened	96	121	96	111	151	30.0	44.5	300
	Cold-drawn	55	76	72	85	106	26.5	50.5	205
	Cold-drawn, age-hardened	102	121	103	120	158	22.0	37.5	330
Inconel	Hot-rolled	31	42	38	47	91	42.0	66.0	160
	Cold-drawn[b]	90	105	99	113	122	19.0	61.5	210
	Cold-drawn, annealed[c]	23	28	29	33	93	42.0	68.0	135
Nickel	Hot-rolled	19	23	20	24	71	44.5	63.0	105
	Cold-drawn[b]	45	58	56	62	87	33.0	72.0	175
	Cold-drawn, annealed[c]	17	26	21	27	73	46.0	79.5	110
"Z" Nickel	Hot-rolled	40	51	44	52	105	40.5	52.5	195
	Hot-rolled, age-hardened	126	148	120	138	177	16.0	22.0	355
	Cold-drawn	67	103	83	107	132	26.5	51.5	245
	Cold-drawn, age-hardened	140	166	134	157	188	14.5	19.0	365

NOTES: [a] Proof stress.
[b] All cold-drawn rods were given a 525 F, low-temperature, stress-equalizing treatment after cold-drawing.
[c] Three hr at 1450 F followed by furnace-cooling.

TABLE 5 SOME HIGH-TEMPERATURE PROPERTIES OF INCONEL

Temperature, F	Creep strength for secondary creep rate of 1.0% elongation per 10,000 hr, psi		Fatigue strength for 10^8 cycles of completely reversed stress, psi	Charpy impact strength, ft-lb
	Condition			
	Hot-rolled	Annealed[a]	Annealed	Annealed
Room	....	....	51500	180
800	....	....	47500	187
900	39000	....		
1000	22000	....	38000	160
1100	11000	....		
1200	5500[b]	5500	30000	160
1300	3000[b]	4000		
1400	1800[b]	3000	15500	154
1500	1100[b]	2000		
1600	710	1500	10000	...
1700	470	1100		
1800	330	640		

NOTES: [a] Two hr at 2000 F followed by quenching in water. [b] By extrapolation.

Freedom from low-temperature brittleness is indicated by impact strength. The Charpy data given in this table show that the high-nickel materials exhibit no appreciable loss in impact strength even though the tensile strength increases considerably.

Fatigue strength and modulus of elasticity of Monel increase at subzero temperatures; the coefficient of thermal expansion of annealed, wrought Monel decreases slightly with decrease in temperature.

MAGNETIC PROPERTIES

The effect of some additive elements upon the Curie point of nickel is shown in Fig. 3. Table 7 summarizes the important magnetic properties of eight of the commercial high-nickel materials of nominal chemical composition.

All specimens for magnetic testing were produced approximately 1/8-in. diameter oversize, machined to size, and flash-pickled in order to eliminate any "skin effect" and contamination with iron from the machining tool. The same specimens

TABLE 6 MECHANICAL PROPERTIES AT LOW TEMPERATURES

Material	Condition	Temperature, F	Yield strength, 0.2% offset, psi	Tensile strength, psi	Elongation in 2 in., per cent	Reduction of area, per cent	Charpy impact strength, ft-lb
Monel	Forged	70	67000	92000	31.0	72.7	216
		—297	91500	128250	44.5	71.8	216
		—423	96400	142000	38.5	61.0	...
	Annealed	70	31300	78650	51.5	75.0	216
		—297	49500	115250	49.5	73.9	212[a]
Nickel	Hot-rolled	70	24600	65600	...	...	195
		—112	27500	76400	...	...	236
		—292	28000	98000	...	...	...
		—310	....	103000	51.0	...	227
Inconel	Hot-rolled	70	....	87000	42.5	71.9	213
		—315	....	116750	51.0	72.7	169
	Cold-drawn, 50% reduction	70	....	145000	10.0	35.1	69
		—315	....	182000	10.0	49.5	61
"K" Monel	Cold-drawn, age-hardened	Room	125900	157300	15.5	37.4	...
		—110	134600	171550	17.3	41.1	...

NOTE: [a] —310 F

TABLE 7 MAGNETIC PROPERTIES

Material	Condition	Tensile strength, psi	Induction, kilogauss at H = 200 oersteds before determination of Curie point	Curie temperature, F, for permeability of 1.01	1.02	1.05	1.1	2
"K" Monel	Soft[a]	92500	1.0011	Below—211	...	...	...	...
	Soft and age-hardened[b]	151000	1.0018	—153	—172	—202	—211	...
	Cold-drawn 20%	137000	1.0011	Below—211	...	...	...	...
	Cold-drawn 20% and age-hardened	186500	1.0019	—128	—151	—153	—183	—210
	Cold-drawn 50%	151250	1.0010	Below—211	...	...	...	...
	Cold-drawn 50% and age-hardened	198000	1.0019	—128	—151	—153	—183	—210
"KR" Monel	Soft[a]	89500	1.0014	...	Below—193	...	...	...
	Soft and age-hardened[b]	129500	1.0020	—121	—157	—181	—208	...
	Cold-drawn 25%	115000	1.0012	Below—125	...	...	...	...
	Cold-drawn 25% and age-hardened	155000	1.0021	—117	—152	—179	—189	...
Inconel	Soft[c]	98000	1.0056	— 17	— 49	—119	—155	...
	Cold-drawn 20%	129000	1.0079	...	— 44	— 94	—139	...
	Cold-drawn 50%	150500	1.0072	...	— 44	— 94	—148	...
	Cold-drawn 50% and stress-equalized[d]	154000	1.0071	— 15	—139	—193	...	...
Nickel	As cast	46000	4.12	...	...	...	...	...
Monel	As cast	71670	1.0282	...	...	+ 64	+ 56	— 21
"H" Monel	As cast	116500	1.0048	— 27	— 69	— 92	—101	—134
"S" Monel	As cast	141500	1.0056	— 27	— 69	— 92	—101	—137
Inconel	As cast	73500	1.0045	—148	...	...	...	...

NOTES: [a] Quenched in water following 45 min at 1550 F.
[b] 16 hr at 1080 F, furnace-cooled to 800 F at 15 deg F per hr and air-cooled.
[c] Quenched in water following 2 hr at 1750 F.
[d] 12 hr at 525 F and air-cooled.

TABLE 8 ELECTRICAL PROPERTIES

Material	Electrical resistivity, room temperature: Ohms per cir mil ft	Microhms, cm³	Temperature coefficient of electrical resistivity, F (68–212 F)	Maximum operating temperature in air (sulphur-free) F
Nickel	57	9.5	0.0024	1900[a]
"Z" Nickel	94.5	15.7	0.002	....
"D" Nickel	110	18.3	0.002	1650
Monel	290	48.2	0.0011	1000[a]
"K" Monel	350	58.3	0.0001	....
"H" Monel	370	61.6	.....	....
"S" Monel	380	63.3	.....	....
80 Nickel–20 (chromium (22)	650	108	0.000049	2100
Inconel	590	98.2	.....	2000[a]
60 Nickel-15 chromium (22)	675	112	0.0000106	1700
Illium G (23)	735	122.5	.....	....
Hastelloy "A" (24)	760	126.7	.....	....
Hastelloy "B" (24)	813	135	.....	....
Hastelloy "C" (24)	800	133	.....	....
Hastelloy "D" (24)	680	113	.....	....

NOTE: [a] Not recommended for use as an electrical heating material.

were used for the determination of permeability and subsequently for the Curie point.

The permeability data were determined with a permeameter, constructed similarly to the Fahy Simplex permeameter described in the Bureau of Standards Circular C-415, checked subsequently at the Bureau of Standards, and found to agree within experimental error.[10] A magnetizing force of H = 200 oersteds was used.

The Curie points were determined[11] by cooling 0.5-in-diameter × 3-in-long specimens in liquid air and then inserting them into a suitable pickup tube which had been cooled previously by a dummy specimen. Simultaneous readings were made of the specimen temperature and the induced voltage as the temperature rose. The external field oscillated between plus and minus 100 oersteds. Corrections were made for demagnetization resulting from the short specimen which reduced the field in the specimen by the relation $H = 100\text{-}K(B\text{-}H)$. The demagnetization factor K for the size of specimen used was 0.032 and becomes appreciable at the higher permeabilities.

Curie points for permeabilities from 1.01 to 2 are reported in Table 7, since in some applications a value of 1.02 maximum

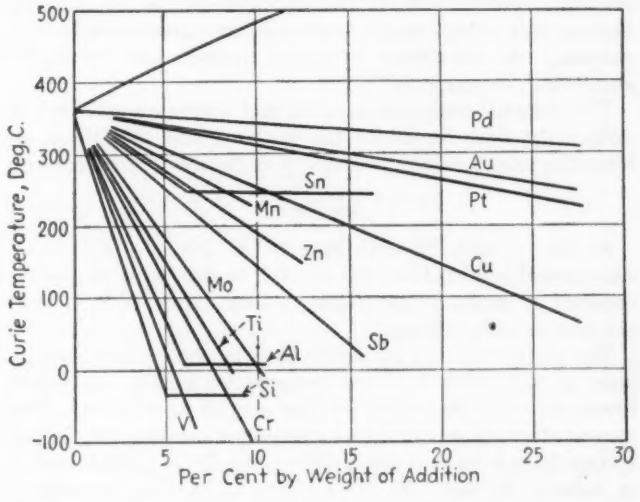


FIG. 3 EFFECT OF SPECIFIC SINGLE ALLOYING ADDITIONS ON THE CURIE POINT OF NICKEL (25)

is required while, in other applications, alloys having a value as high as 2 or 5 may be sufficiently nonmagnetic to be useful. Measurements of permeability, at H = 200 oersteds, after determinations of the Curie points showed no change in values due to the severe cooling.

The permeabilities of "K" Monel and "KR" Monel are not affected by cold-working or by age-hardening. On the basis of μ = 1.02 maximum (air), these age-hardened alloys can be used safely down to —150 F. The permeability of Inconel varies with cold work and thermal treatment; a useful value for commercial work, μ = 1.02 maximum, is —40 F. Cast nickel is quite strongly magnetic and cast Monel is weakly magnetic. The two silicon-Monel alloys, "H" Monel and "S" Monel, and Inconel are substantially nonmagnetic.

[10] Private communications from Dr. John A. Bennett, Bureau of Standards, Washington, D. C., and C. G. Bieber, Huntington Works, The International Nickel Co., Inc., Huntington, W. Va.
[11] Unpublished results of E. M. Wise and T. E. Skinner, The International Nickel Co., Inc., New York 5, N. Y.

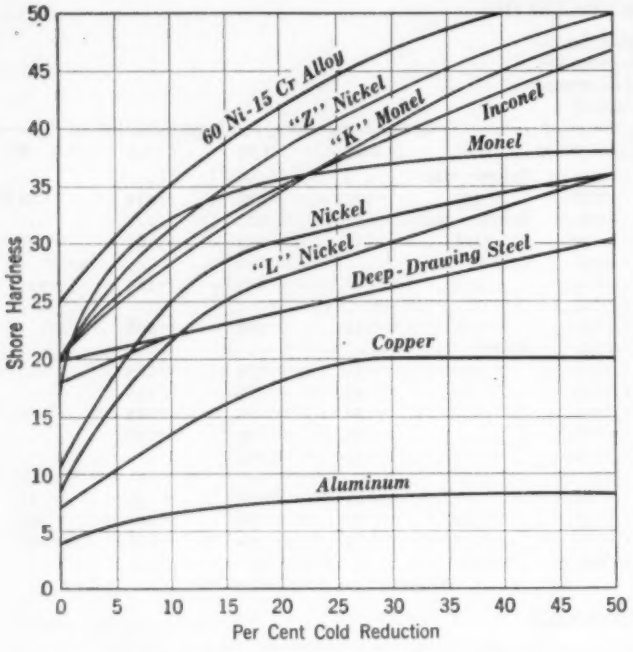


FIG. 4 INCREASE IN HARDNESS OF VARIOUS METALS AND ALLOYS WITH COLD-WORKING

ELECTRICAL PROPERTIES

Values for resistivity and temperature coefficients are given in Table 8.

The 80–20 and the 60–15 type nickel-chromium alloys are the only materials included in this summary which have been developed particularly to give optimum life as an electrical heating unit at high temperatures and are recommended for the purpose; the maximum operating temperatures are 2100 F and 1700 F, respectively.[12]

The chemical composition of Inconel is not controlled within sufficiently close limits for the purpose, and the Illium and Hastelloy alloys oxidize too rapidly at the service temperatures.

SPRINGS

A series of tests (5) with Monel, "K" Monel, "Z" Nickel, and Inconel was made at 300 to 700 F to determine the stresses required to produce relaxations, or load losses, of 2, 4, and 6 per cent in coiled springs.

The performance of Inconel springs is outstanding, particularly at 500 to 700 F, when designed for average or slightly lower stresses, depending on the service conditions. With conservative stresses and low number of oscillations, Inconel springs have been used successfully up to 750 F. With average or reduced stresses, "Z" Nickel may be used at temperatures up to 550 F, "K" Monel up to 500 F, and Monel up to 400 F. The stresses should be governed by the existing service conditions. "Z" Nickel and "K" Monel will withstand higher stresses than Inconel at the lower temperatures, consistent with their higher level of mechanical properties.

FABRICATION

Wartime extension of the use of the high-nickel alloys has given the personnel of many manufacturing and fabricating plants its first experience in fabricating the materials. Welders, drop forgers, machinists, and sheet-metal workers, experienced in the fabrication of steel, have modified standard steel-working equipment and methods to handle these nonferrous materials satisfactorily. The working methods are founded on the chemical composition, mechanical properties, and physical constants of the materials, particularly strength, hardness, toughness, and thermal conductivity.

The high-nickel materials are stronger, harder, tougher, and work-harden more rapidly than low-carbon steel, copper, brass, aluminum, and aluminum-base alloys. In general, fabrication methods are more similar to those used for steel than for the softer nonferrous materials. Heavier equipment is required for forging, deep drawing, and spinning, and the materials must be annealed more frequently during the cold-working operations.

In the hot-working operations, the high melting points of the nickel materials require temperatures which are practically identical with those used for steel and, in addition, atmospheres which are sulphur-free because of the embrittling effect of this element upon nickel. Annealing temperatures for all the high-nickel materials except pure nickel are considerably higher than those required for steel. Bright-annealing is easier than with steel because the nickel materials oxidize less readily. The procedure for age-hardening is essentially the opposite of that for steel; the nickel materials are soft when quenched from high temperatures and are hard when held at, and cooled from, intermediate temperatures. The different physical and mechanical characteristics of the nickel materials require slight modifications in welding to insure adequate fusion and penetration and to prevent buckling. Resistance welding requires less current because of the high electrical resistivity which is associated with most high-nickel alloys, particularly those containing chromium and molybdenum.

The high-nickel materials are not difficult to machine, although different combinations of toolings, speeds, feeds, and cutting compounds are required from those used with steel or brass. The methods for deep drawing, spinning, shearing, perforating, and tube and pipe fabrication require but little modification of the standard technique for steel. Pickling is quite different because the high-nickel materials are strongly resistant to many acids, particularly those used for steel and the high-copper alloys.

Details (6) (7) and practical procedures for heating (8), forging (8), annealing (9), stress equalizing (10), age-hardening (11), welding (12) (13), brazing (12), soldering (12), deep drawing (14), spinning (6), machining (15) (16), precision grinding (6) (17), shearing (14), perforating (14), tube and pipe fabrication (18), forming heavy equipment (19) (20), pickling (21), and polishing (6) are given in other publications.

CONCLUSIONS

1 Chemical compositions, mechanical properties, physical constants, magnetic and electrical properties are given for nickel and 18 high-nickel corrosion-resisting and heat-resisting alloys.

2 All materials have good mechanical properties, evidenced by a high ratio of strength to ductility, over a wide range of temperatures.

3 Useful nonmagnetic characteristics of six materials are summarized.

4 Electrical resistivity of most of the alloys is given and the special use of two materials as electrical heating units is indicated.

5 References are cited where further details, particularly methods of fabrication and treatment, may be secured.

BIBLIOGRAPHY

1 "Engineering Alloys," by N. E. Woldman and A. J. Dornblatt, American Society for Metals, Cleveland, Ohio, 1936.

2 "Compressive, Impact, and Other Mechanical Properties of Nickel and Some of Its High-Strength, Corrosion-Resisting Alloys," by C. F. Catlin and W. A. Mudge, Proceedings, A.S.T.M., vol. 38, 1938, part II, pp. 269–276.

[12] Private communication from G. H. Stauffer, Driver-Harris Co., Harrison, N. J.

3 "Creep Properties of Cold-Drawn Annealed Monel and Inconel," by B. B. Betty, H. L. Eiselstein, and F. P. Huston, Jr., American Institute of Mining and Metallurgical Engineers, Technical Publication No. 1775, 1944.

4 "High Properties at Low Temperatures," by W. A. Mudge, *Inco*, vol. 19, 1944, pp. 18–20.

5 "Relaxation Resistance of Nickel-Alloy Springs," by B. B. Betty, E. C. McQueen, and Carl Rolle, Trans. A.S.M.E., vol. 64, 1942, pp. 465–473.

6 "The Fabrication and Treatment of Nickel and High-Nickel Alloys," by W. A. Mudge, Trans. Canadian Institute of Mining and Metallurgy, vol. 46, 1943, pp. 506–534.

7 "The Working of High-Nickel Alloys," *American Machinist*, vol. 86, 1942, pp. 885–904.

8 "Forging Monel, 'K' Monel, Nickel, 'Z' Nickel, and Inconel," Technical Bulletin T-11, August, 1941, The International Nickel Co., Inc., New York 5, N. Y.

9 "Annealing Nickel, Monel, and Inconel," Technical Bulletin T-20, June, 1941, The International Nickel Co., Inc., New York 5, N. Y.

10 "Stress-Relief Annealing of Monel Plate," by Peter R. Kosting, Proceedings A.S.T.M., vol. 36, 1930, pp. 222–230.

11 "The Heat-Treatment of 'K' Monel and 'Z' Nickel," Technical Bulletin T-16, November, 1943, The International Nickel Co., Inc., New York 5, N. Y.

12 "Welding, Brazing, and Soft Soldering of Monel, Nickel, and Inconel," Technical Bulletin T-2, June, 1940, The International Nickel Co., Inc., New York 5, N. Y.

13 "The Spot Welding of Nickel, Monel, and Inconel," by Wendell F. Hess and Albert Muller, *The Welding Journal*, Welding Research Supplement, vol. 20, pp. 417s–426s. 1941. Also, "The Flash Welding of Nickel and High-Nickel Alloy Rod," by Wendell F. Hess and Albert Muller, *The Welding Journal*, vol. 22, 1943, pp. 532s–544s.

14 "The Deep Drawing, Shearing, and Perforating of Monel, Nickel, and Inconel," Technical Bulletin T-19, December, 1940, The International Nickel Co., Inc., New York 5, N. Y.

15 "Machining Monel, "K" Monel, "R" Monel, "KR" Monel, Inconel, and Nickel," Technical Bulletin T-12, April, 1942, The International Nickel Co., Inc., New York 5, N. Y.

16 "Machining 'S' Monel Castings on Turret-Lathe Equipment," Anon., *Screw Machine Engineering*, vol. 3, 1942, pp. 27–31.

17 "Centerless Grinding of High-Nickel Alloys," by John H. Jaecker, *Machinery*, vol. 47, 1941, pp. 115–116.

18 "Fabrication of Monel, Nickel, and Inconel Seamless Pipe and Tubing," Technical Bulletin T-17, October, 1940, The International Nickel Co., Inc., New York 5, N. Y.

19 "Design and Construction of Heavy Equipment in Monel, Nickel, and Inconel." Technical Bulletin T-14, August, 1938, The International Nickel Co., Inc., New York 5, N. Y.

20 "Methods for the Fabrication of Clad Steel Plate," Technical Bulletin T-4, October, 1941, The International Nickel Co., Inc., New York 5, N. Y.

21 "Pickling Nickel, Monel, and Inconel," Technical Bulletin T-21, November, 1943, The International Nickel Co., Inc., New York 5, N. Y.

22 "R-40 Data Book on Electrical Heat- and Corrosion-Resisting Alloys," Driver-Harris Co., Harrison, N. J., and private communications, G. H. Stauffer, Driver-Harris Co.

23 "Illium—A Useful Corrosion-Resistant Alloy," Technical Bulletin 104-B, September, 1942, Burgess-Parr Co., Freeport, Ill.

24 "High-Strength, Nickel-Base Alloys for Corrosion Resistance," Technical Bulletin, 1940, Haynes Stellite Co., Kokomo, Ind., and private communications, F. S. Badger, Haynes Stellite Co.

25 "The Properties of Pure Nickel," by E. M. Wise and R. H. Schaefer, *Metals and Alloys*, vol. 16, 1942, pp. 424–428, 891–893, 1067–1071.

Trends in the Use of

WELDED MACHINERY PARTS

(*Continued from page 118*)

Weldments procured by or for government agencies, for instance, are clearly specified, and type, extent, and control of inspection are fairly well developed. On the other hand, specifications on commercial welded machinery parts are too often quite general and meager, and this causes discouraging delays in pricing and final design.

It would seem that valuable and important work can be done here by a co-ordinating agency, since there is splendid opportunity for the compilation and correlation of design criteria.

As mentioned, nomenclature is comparatively well developed and welding symbols are standardized. But there are somewhat complex items of specification on a welded machinery part in contrast to those on a casting. The following requirements are a few of those which must be determined and specified in the design and construction of any welded machinery part:

What type of weld joint shall be used and where? Much remains to be done in the evaluation of types of joints before the basis of this specification is available.

What type of electrodes shall be used and where?

What method of inspection shall be used and where?

What are the standards for such inspection?

How and to what degree shall the weldment be tested?

Should it be stress-relieved?

What tolerance can be expected and where?

Today the codes and standards of many agencies overlap in the specification of welded machinery parts. It is reasonable to assume that none is adequate for they were established for other purposes.

It is the author's conviction that the commercial designer literally has no guiding standards with the exception of nomenclature. It is inconceivable that he does not at times apply weldments in which faulty design endangers human life.

It has become common procedure for the user to rely on the supplier to develop his specifications for him, but there is nothing alarming in this if fundamental standards are available.

Specifications undoubtedly are guided often by equipment limitations, inventories, geographical location, individual experience or the lack of it, or ill-advised convictions.

All these can generate a rather chaotic, unstabilized condition in the industry, assuming that the production of welded machinery parts properly can be termed an industry. Costs and prices are widely divergent and will so remain until fundamental specification standards are devised and promulgated.

Much experience and basic information with service records as a sound foundation exist. Ultimately valuable work will be done in its compilation, correlation, and in filling of the gaps.

It would seem reasonable to conclude that the entire subject is one of mechanical engineering. This is true since we are considering only mechanical parts.

A.S.M.E. HEAT TRANSFER DIVISION

Its Development, Objectives, and Operation

HEAT transfer as an engineering operation has come into its place of vital technical importance through its fundamentally essential role of bearing upon, or contributing to, the manufacture of all types of products, and the functioning of all manner of industrial processes. The design and manufacture of heat-transfer equipment has attained the status of an industry of significant proportions, in direct response to the demand and technical progress represented by such activity. The progressive trend toward more exacting specifications for the design and performance of specialized heat-transfer equipment has fostered the establishment and growth of a considerable body of organized heat-transfer knowledge, available to serve as the basic means of accomplishing these developments.

INSPIRATION FOR ORGANIZING HEAT TRANSFER GROUP

Engineering has accorded to heat transfer its strong and important position principally because of its bearing upon the consequences of the economic and processing value of thermal energy. The generation, harnessing, conversion, conservation, and regulation of thermal energy represent engineering problems and activities of the most fundamental and essential nature. Horizons in the domain of applied heat transfer lead out in all directions through science and industry, encompassing every nature of related field, from the most recent aspects of fundamental physics to the invaluable experiences and practices of large-scale processing or manufacture. Everywhere, spreading broadly from the essentials of natural phenomena to the achievements of improved living and the accomplishments of science and industry, the transfer of thermal energy has its continual part to play.

It has been in due recognition of the essential role of heat transfer, and the development of a body of organized technical data bearing thereon, that the Heat Transfer Division of the A.S.M.E. has been formed to serve as a centralizing group for the professional, industrial, and academic interchange of heat-transfer information. Diversified activities have been established by the Division to enhance the rapid growth of the entire field of data, principles, practices, and experiences on a national scale. Opportunities are provided for the practicing engineer to keep abreast of all the latest information and experiences in industry. The Division also aims to cover the basic scientific aspects thoroughly with emphasis upon coming industrial developments and current fundamental problems. Particular benefits here are offered to the recent graduate for his industrial adjustment.

In paying tribute to the fundamental aspects of heat transfer as an engineering science, a large share of its importance is attained in practice through its interrelations with the principles and applications of the companion engineering sciences of fluid mechanics and thermodynamics. Industrial operations which require the simultaneous application of physical principles from these related basic fields are quite common and important in occurrence. This is further attested to by the considerable number of research projects, of both industrial and academic sponsorship, which have come to be undertaken in heat transfer and these companion sciences during recent years. The challenging problems of experimental heat transfer encountered here in both research and industrial work have fostered the development of many exacting experimental techniques, from among which important principles of instrumentation, testing, and process control have been developed.

On all fronts, from science through industry and economics, important problems of all degrees of complexity, involving heat-transfer sections in an unlimited variety of requirements, are in need of continual engineering attention. The Heat Transfer Division promises to serve at its best, in the interests of all concerned, to the attainment of these opportunities for progress. In this article, the history and basis of this pledge will be outlined.

EVOLUTION OF HEAT TRANSFER DIVISION

Heat-transfer papers, in various forms, have appeared in the publications of the Society from the very beginnings of engineering interest in the subject. The more intensified broadening of interest in the field, which took place during the 1920's, in parallel with industrial growth, brought membership interest and the number of papers presented to such a level that, in 1934, a Heat Transfer Committee was formed within the Process Industries Division of the Society.

Expanding interest and intensified industrial requirements, however, soon outgrew the committee stage, so at the time of the Society's Annual Meeting in 1937, the heat-transfer interests were formally launched to stand by themselves as the Heat Transfer Professional Group, established under the Basic Science Department of the Standing Committee on Professional Divisions. That this Group should have been established as a basic science unit at that time was in accord with the nature of heat transfer and the natural consequence of its evolution as a major industrial activity, for the preceding decade had been one in which the scientific foundations of all fields of engineering had received considerable attention.

Technical sessions sponsored by this new Group at Society meetings drew strong support, and a steady succession of interesting papers served to establish a sound reputation for the Group and its activities. A large share of the success of this development may be attributed to the thorough groundwork and careful planning for the future which were the guiding principles of the relatively small coalition of engineers who actively guided this formative period. Always, the nature of the subject field has served as an excellent forge for the common interests of diversified activities, and this has proved to be an unusually strong basis of organization.

The functional organization and activities of the Group were guided by a carefully drawn set of By-Laws,[1] first issued in June, 1938. These By-Laws proved to be so successful as a governing structure that they have been carried through essentially intact to continue in force for the present Heat Transfer Division.

Full Professional Division status was attained by the Group through action of the A.S.M.E. Standing Committee on Professional Divisions early in 1941. This was accomplished on the basis of extensive participation in meetings, and a nation-wide engineering interest established for heat transfer. Both registered fields of interest from among A.S.M.E. members and general full-fledged industrial recognition served to support and guide this move.

ORGANIZATION AND OPERATION OF DIVISION

With this background of successful development, it is next in order to summarize the organization and operation of the Division. The stated objectives of the Division have been established on the basis that few indeed are the engineering activities which do not require formal consideration of heat

[1] Copies of current By-Laws are available on request.

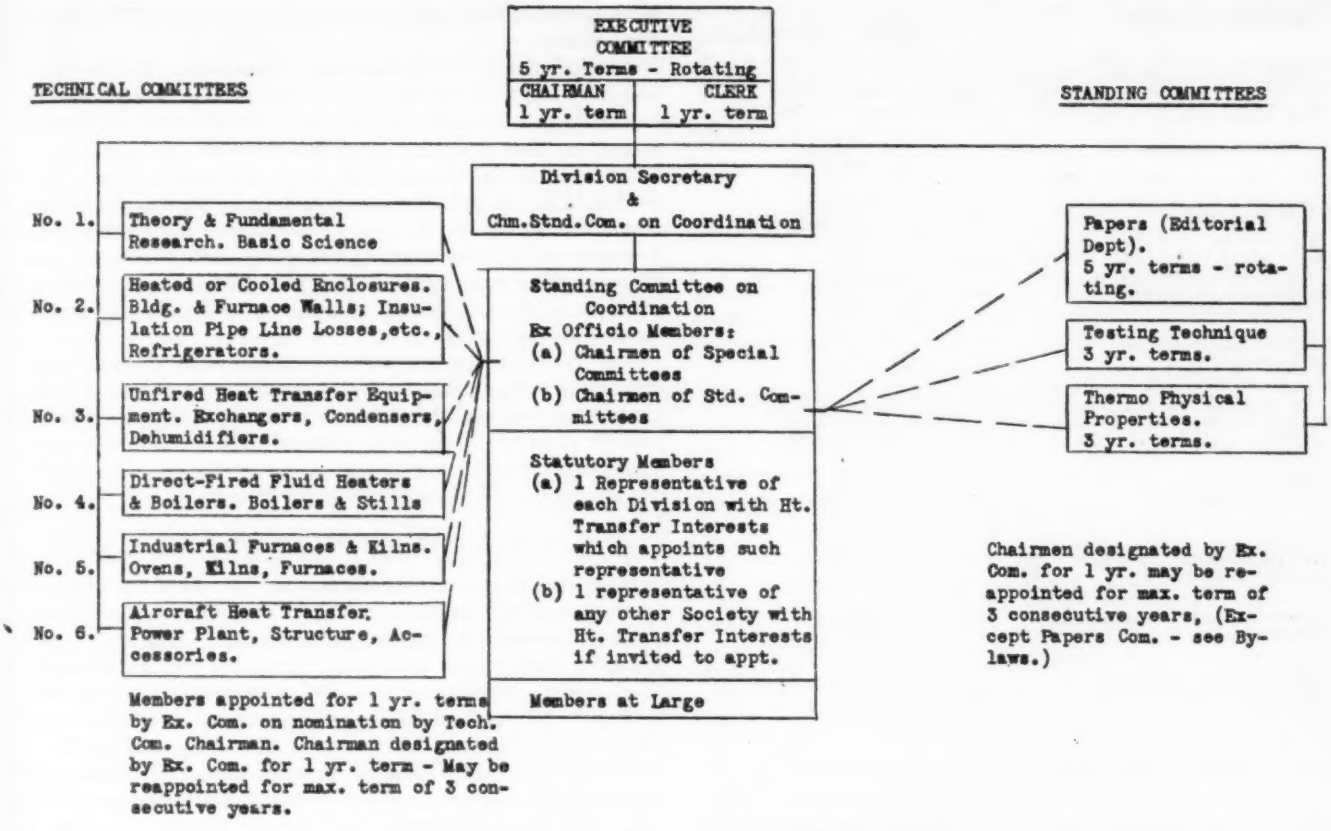

EXECUTIVE COMMITTEE
5 yr. Terms - Rotating
CHAIRMAN 1 yr. term
CLERK 1 yr. term
TECHNICAL COMMITTEES
STANDING COMMITTEES
Division Secretary & Chm.Stnd.Com. on Coordination
No. 1. Theory & Fundamental Research. Basic Science
No. 2. Heated or Cooled Enclosures. Bldg. & Furnace Walls; Insulation Pipe Line Losses,etc., Refrigerators.
No. 3. Unfired Heat Transfer Equipment. Exchangers, Condensers, Dehumidifiers.
No. 4. Direct-Fired Fluid Heaters & Boilers. Boilers & Stills
No. 5. Industrial Furnaces & Kilns. Ovens, Kilns, Furnaces.
No. 6. Aircraft Heat Transfer. Power Plant, Structure, Accessories.
Members appointed for 1 yr. terms by Ex. Com. on nomination by Tech. Com. Chairman. Chairman designated by Ex. Com. for 1 yr. term - May be reappointed for max. term of 3 consecutive years.
Standing Committee on Coordination
Ex Officio Members:
(a) Chairmen of Special Committees
(b) Chairmen of Std. Committees
Statutory Members
(a) 1 Representative of each Division with Ht. Transfer Interests which appoints such representative
(b) 1 representative of any other Society with Ht. Transfer Interests if invited to appt.
Members at Large
Papers (Editorial Dept). 5 yr. terms - rotating.
Testing Technique 3 yr. terms.
Thermo Physical Properties. 3 yr. terms.
Chairmen designated by Ex. Com. for 1 yr. may be reappointed for max. term of 3 consecutive years, (Except Papers Com. - see By-laws.)

FIG. 1 HEAT TRANSFER DIVISION ORGANIZATION CHART

(Special Committee No. 7 was authorized in December, 1944, entitled "Nomenclature and Symbols.")

transfer in some degree; and thus it has been undertaken to extend the scope and benefits of the Division's organization and services to all who share this common interest. Quoted directly from the By-Laws, the Division objectives are as follows:

1 To constitute a Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS interested in the improvement of the design and operation of all classes of heat-transfer equipment.

2 To promote the exchange of information concerning the principles of heat transfer and the supporting data.

3 To encourage experimental and theoretical investigations of the principles of heat transfer, and to foster improvements in the technique of testing heat-transfer equipment to the end that reliable numerical evaluation of these principles may be effected.

4 To disseminate information on heat transfer through the presentation, discussion, and publication of reliable papers by individuals, and of reports by technical committees; to summarize and publish data on the thermophysical properties of substances, especially those of engineering importance.

5 To serve and co-operate with other Groups and Divisions of the Society and with other organizations having related interests in the field of heat transfer.

Direction of the activities and policies of the Division is accomplished by an Executive Committee of five members. Some one of the committee members is elected each year by the committee to serve as its chairman, which office automatically is synonymous with that of Chairman of the Division. Also, one of the Executive Committee members is elected by the committee to serve as clerk; he keeps all records of the committee and otherwise serves in the capacity of its secretary in all official committee procedures. The designation of "clerk" is employed in order to avoid confusion with the Division Secretary, which is a separate office.

Further to assist with advice and contacts on all manner of problems, a group of not more than five Advisory Associates is appointed by the Executive Committee; these men need not be members of the Society, as they are selected by reason of their special experience or attainments in the heat-transfer field. The Advisory Associates meet with the Executive Committee and have a voice in its proceedings, although they have no vote.

An organizational feature of particular interest is the position of the Division Secretary. He is appointed by the Executive Committee from outside of their membership and remains responsible to them and to Society Headquarters. The Secretary handles correspondence on all general matters of Division business, prepares the Annual Report of the Division, and serves as chairman of the Division's Co-ordination Committee.

The By-Laws provide for the functional framework of the Division to be established by the Executive Committee in the form of appointments to: (1) certain standing committees, the duties of which are specified by the By-Laws; and (2) "such special committees as the work of the Division may require." Thus the standing committees are either administrative in nature or deal with problems of general importance in the heat-transfer field which require continuity of program. The special committees, which are designated as "technical committees," are assigned to cover specific subdivisions of the field, and they represent the major broadening effort in carrying out the objectives of the Division. It is to be noted that the technical committees are not automatically perpetuated; for their status is reviewed annually by the Executive Committee, and they may be dissolved when they are no longer needed. A further feature of the technical committees is the fact that the

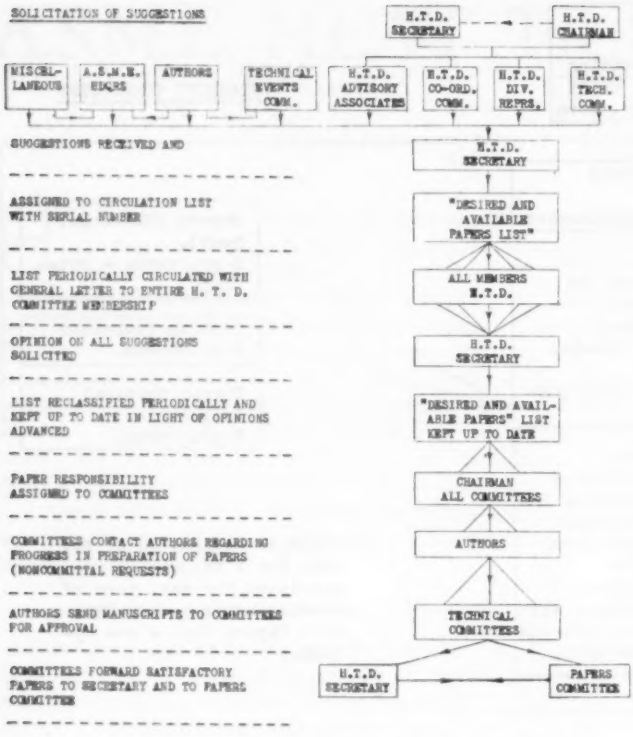

SOLICITATION OF SUGGESTIONS
H.T.D. SECRETARY
H.T.D. CHAIRMAN
MISCEL-LANEOUS
A.S.M.E. HDQRS
AUTHORS
TECHNICAL EVENTS COMM.
H.T.D. ADVISORY ASSOCIATES
H.T.D. CO-ORD. COMM.
H.T.D. DIV. REPRS.
H.T.D. TECH. COMM.
SUGGESTIONS RECEIVED AND
H.T.D. SECRETARY
ASSIGNED TO CIRCULATION LIST WITH SERIAL NUMBER
"DESIRED AND AVAILABLE PAPERS LIST"
LIST PERIODICALLY CIRCULATED WITH GENERAL LETTER TO ENTIRE H. T. D. COMMITTEE MEMBERSHIP
ALL MEMBERS H.T.D.
OPINION ON ALL SUGGESTIONS SOLICITED
H.T.D. SECRETARY
LIST RECLASSIFIED PERIODICALLY AND KEPT UP TO DATE IN LIGHT OF OPINIONS ADVANCED
"DESIRED AND AVAILABLE PAPERS" LIST KEPT UP TO DATE
PAPER RESPONSIBILITY ASSIGNED TO COMMITTEES
CHAIRMAN ALL COMMITTEES
COMMITTEES CONTACT AUTHORS REGARDING PROGRESS IN PREPARATION OF PAPERS (NONCOMMITTAL REQUESTS)
AUTHORS
AUTHORS SEND MANUSCRIPTS TO COMMITTEES FOR APPROVAL
TECHNICAL COMMITTEES
COMMITTEES FORWARD SATISFACTORY PAPERS TO SECRETARY AND TO PAPERS COMMITTEE
H.T.D. SECRETARY
PAPERS COMMITTEE

FIG. 2 FLOW CHART FOR PAPERS SUGGESTIONS

chairmen may designate such subcommittees from among their committeemen as may be found desirable. Fig. 1 is a chart presenting the organization of the Heat Transfer Division.

The objectives of the individual committees are, within their respective fields, those of the Division as a whole. The six technical committees currently in existence cover most of the common subdivisions of practice in relation to prevailing interest. Technical Committee No. 1 is of basic importance. Nos. 2, 3, 4, and 5 cover widespread commercial and industrial fields. No. 6 is specially assigned to the aircraft industry, in acknowledgment of the vital importance of that field, and the number of engineers employed therein, for both wartime and postwar periods. Other activities of this latter nature may be established whenever necessary to fill an existing need in industrial developments.

The primary duty of each committee is to bring to the Society's programs and publications important and representative papers within its sphere of interest. These papers are chosen with the object of bringing promptly to the attention of the Society conclusions drawn from practical applications, as well as significant theoretical or research work, and design or testing techniques.

PANEL-DISCUSSION SESSIONS INTRODUCED

Recent meetings under wartime conditions have seen the popular growth of another type of committee-sponsored activity, i.e., "panel-discussion" session. Here are brought together, in a completely informal atmosphere, problems and topics of current interest for organized discussion. Committees may also sponsor entire technical sessions, or a symposium of papers to be presented at Society meetings whenever widespread interest arises.

Turning particularly to the functioning of the standing committees, the Co-ordination Committee is of great importance. This committee serves as the working liaison between the Heat Transfer Division and all other Divisions and Groups of the Society, as well as with any other society having common interests in the field. A further activity of this committee is that of seeking out and maintaining informative contacts with pertinent heat-transfer research investigation throughout the country.

As Chairman of the Co-ordination Committee, the Division Secretary sees to it that each individual member of all standing and technical committees is kept currently informed of Division activities, problems, and programs through the issuance of several general letters each year, copies of which are also sent to A.S.M.E. headquarters, the Standing Committee on Professional Divisions, the Advisory Associates, and the Executive Committee; thereby covering the entire field of activity and representation with up-to-the-minute information and notices of advance plans. This practice has proved to be very satisfactory in all respects.

The standing committees on "Testing Techniques" and "Thermo-Physical Properties," respectively, serve to provide centralized continuity for these fundamental aspects of heat-transfer activity. Critical reviews of practices and data, compilation of special reports, and recommendation of standards are among the objectives of these committees.

PROCEDURE OF COMMITTEE ON PAPERS

Of particular general interest may be the procedure followed by the Standing Committee on Papers as it functions to review, or have reviewed by outside experts, all papers presented to the Division. An important feature of organization in this connection is the fact that the Division operates in such a way as to relieve the Papers Committee of all responsibility for the actual solicitation of papers, that responsibility being the domain of the other standing and technical committees. This leaves the Papers Committee free to do a thorough and unbiased reviewing job. The Papers Committee exercises the authority to reject a paper or request its revision; and in the case of acceptable papers, its recommendation must be given the approval of the Executive Committee. Rigid standards of quality are maintained.

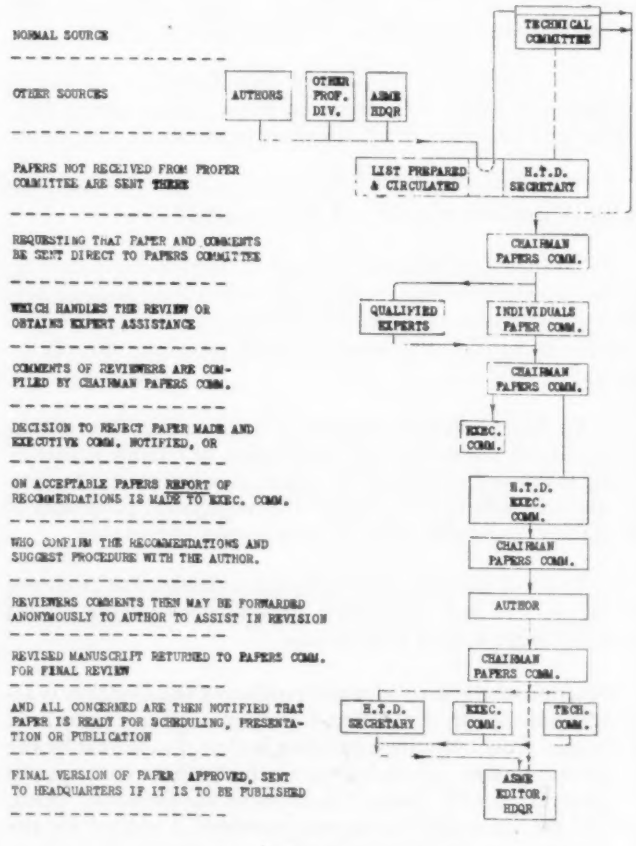

NORMAL SOURCE
TECHNICAL COMMITTEE
OTHER SOURCES
AUTHORS
OTHER PROF. DIV.
ASME HDQR
PAPERS NOT RECEIVED FROM PROPER COMMITTEE ARE SENT THERE
LIST PREPARED & CIRCULATED
H.T.D. SECRETARY
REQUESTING THAT PAPER AND COMMENTS BE SENT DIRECT TO PAPERS COMMITTEE
CHAIRMAN PAPERS COMM.
WHICH HANDLES THE REVIEW OR OBTAINS EXPERT ASSISTANCE
QUALIFIED EXPERTS
INDIVIDUALS PAPER COMM.
COMMENTS OF REVIEWERS ARE COMPILED BY CHAIRMAN PAPERS COMM.
CHAIRMAN PAPERS COMM.
DECISION TO REJECT PAPER MADE AND EXECUTIVE COMM. NOTIFIED, OR
EXEC. COMM.
ON ACCEPTABLE PAPERS REPORT OF RECOMMENDATIONS IS MADE TO EXEC. COMM.
H.T.D. EXEC. COMM.
WHO CONFIRM THE RECOMMENDATIONS AND SUGGEST PROCEDURE WITH THE AUTHOR.
CHAIRMAN PAPERS COMM.
REVIEWERS COMMENTS THEN MAY BE FORWARDED ANONYMOUSLY TO AUTHOR TO ASSIST IN REVISION
AUTHOR
REVISED MANUSCRIPT RETURNED TO PAPERS COMM. FOR FINAL REVIEW
CHAIRMAN PAPERS COMM.
AND ALL CONCERNED ARE THEN NOTIFIED THAT PAPER IS READY FOR SCHEDULING, PRESENTATION OR PUBLICATION
H.T.D. SECRETARY
EXEC. COMM.
TECH. COMM.
FINAL VERSION OF PAPER APPROVED, SENT TO HEADQUARTERS IF IT IS TO BE PUBLISHED
ASME EDITOR, HDQR

FIG. 3 FLOW CHART FOR PAPERS

Division policies recognize that it is desirable that each prospective author be advised of a good form and submission procedure for his paper in advance of its submission. The steps in launching a paper which have been set up by the Heat Transfer Division are as follows:

1 Papers are normally solicited in the name of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, through committee personnel, in recognition of what is established as good form and material content.

2 Papers are usually submitted for preliminary approval and recommendations to the proper committee chairman. Due committee credit and sponsorship may be assigned in this way.

3 Papers are then sent to the Papers Committee for its detailed review and recommendations.

4 Papers must be approved by the Executive Committee before final programming; and by the A.S.M.E. Committee on Publications before publication.

Every effort is extended on the part of the Division to assist the author in producing a good paper. Special notices, giving suggestions to prospective authors, have been prepared by the Division.[2] Reference is also made to the approved A.S.M.E. standards and requirements, to Society recommendations in the leaflet, "Suggestions to Authors," (1939), and to past-published papers as examples of approved practice. Also, where the paper is one dealing with original experimental work, the Division is particular in its request that complete original data be included.

The author is further advised concerning the necessary time schedules for papers to meet dead lines, and the special requirements pertaining to the recently adopted photo-offset method of preprinting.

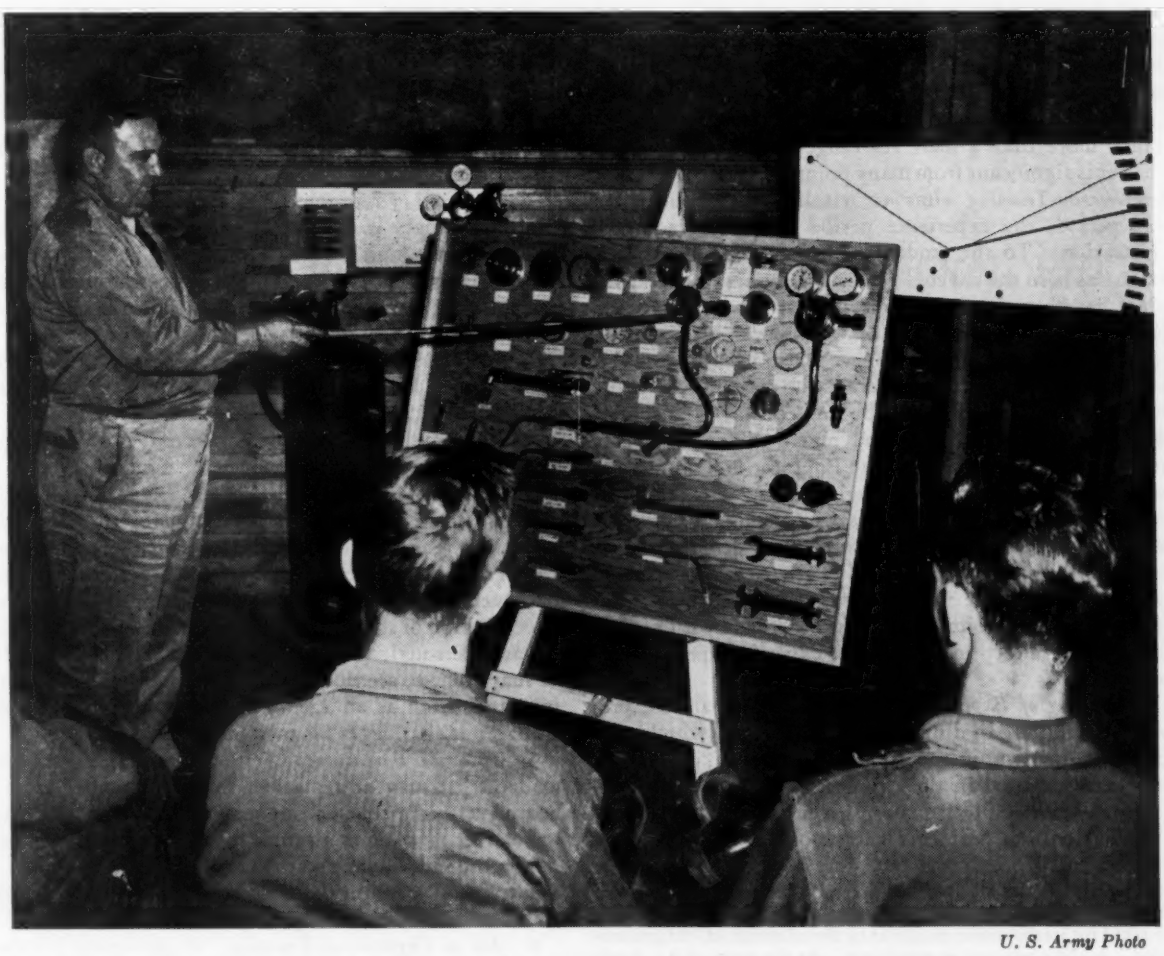
For particular clarity and emphasis, the sequence and nature of the procedures followed in connection with the solicitation and review of papers have been illustrated in graphical flow-chart form, Figs. 2 and 3.

[2] Sample copies are available on request.

FUTURE PROSPECTS FOR DIVISION

In contemplating the future, the Heat Transfer Division offers an opportunity for fellowship, service, and technical advancement of broad promise. Those interested in the heat-transfer field will find in the Division a means of keeping in close touch with the latest applied developments in industry, current presentations of design data and methods, information on advances in experimental techniques, reliable sources of physical data, newly developed methods of analysis, and the most recent advances in the basic-science aspects of heat transfer. Plans for the future are being formulated with emphasis upon the vision of a strong research position for the Division on a national scale, with interdivisional and intersociety cooperation pledged as a goal for the fundamental benefits to all concerned. In this direction lie far-reaching potentialities for the broadening of understanding and utilization of heat transfer in American engineering circles.

Indeed, heat transfer has come strongly into its own as an engineering operation which combines all the stimulating qualities of an art and a science, in a challenge to improvements of economy and performance wherever thermal energy is involved in any form or manner. In due recognition of this fact, the entire organization of the Heat Transfer Division has been established and dedicated to its objectives.



U. S. Army Photo

CLASSROOM SCENE IN THE QUARTERMASTER BLACKSMITH AND WELDING SCHOOL OF CAMP LEE'S ARMY SERVICE FORCES TRAINING CENTER

(George D. Foulkrod, of Petersburg, Virginia, instructor at the school, is pointing out a diaphram used to regulate the working pressure of an acetylene welding torch. The board contains a complete welding and cutting outfit.)

ENGINEERS-IN-TRAINING

An Innovation of Far-Reaching Significance

By CHARLES F. SCOTT[1]

"ENGINEERS-in-Training," in brief, permits candidates for registration by the State Engineering Examining Board to take part of the examination—that in fundamental engineering subjects—before the completion of the experience period of four years or more, i.e., at any time following graduation from an accredited course (or completion of satisfactory preliminary experience). To those who pass this examination a certificate is issued; registration then awaits completion of experience and the final examination.

The foregoing provision was added to the "Model Law," in the 1943 revision which is endorsed by leading engineering societies for adoption by the several states. The National Council of State Boards of Engineering Examiners, at its 1944 annual meeting, recommended to State Boards favorable consideration of the Engineers-in-Training program.

New York changed its rules and inaugurated Engineers-in-Training in 1943. There have been three examinations, at each of which approximately sixty per cent of sixty candidates passed. Iowa has likewise modified its rules. Ohio has changed its law, effective in 1946, to provide for Engineers-in-Training and the examination of all candidates. Georgia, Minnesota, and Missouri are making necessary provision by changes in law or rules; and seven other states are actively considering provision for Engineers-in-Training. Engineers-in-Training is a part of the engineering profession in certain of the provinces in Canada.

The new plan, involving the preliminary examination, portends much more than a mere rearrangement of examination schedules; it is significant from many points of view:

1 *Engineers-in-Training* aims to vitalize the critical but neglected period, the experience period between graduation and registration. To the student in the engineering school, graduation has been the coveted goal of four years of study; his curriculum has been clearly defined; instructors have been expert guides; the whole environment subserves his progress. After graduation the young engineer must usually find his own way; objectives are vague; there are no specified curricula; environment may be depressing; he finds obstacles and must make detours; guideposts are few and human guides are largely accidental. But when he becomes an Engineer-in-Training, he acquires a new and definite goal—registration. His task now is by self-development to qualify as a professional engineer. And as his own aims and efforts become more definite, others may be more ready to guide and aid. The experience period may awaken constructive interest as its significance is better recognized. Formal recognition is now accorded by Engineers-in-Training; it is a step in placing the experience period on a new basis.

2 *The Meaning of Experience.* The two examinations, preliminary and final, are of different types; the first, which may be taken immediately after the diploma is received, deals with what has been acquired in the engineering school. This examination may not duplicate those given in specific subjects before graduation, but problems may be of the comprehensive type involving several branches of engineering; emphasis may be laid less on manipulation and more on application; problems relating to actual structures or plants or machines or processes may indicate a shift from "abstract" theory to concrete reality. The *final* examination following the experience period should ascertain the development during this period of experience. Enlistment as an Engineer-in-Training with credit for the examination in "fundamentals" prompts the query as to what new things should be acquired in the experience period to qualify for the coming examination. Just what is the experience period expected to add to one's capability? Just what kind of experience does the Board deem "satisfactory?" It may not be the skill acquired for doing certain things, but rather a by-product of general engineering competency, such as intellectual independence with ability to think and to act without minute direction, facility in handling a problem by analyzing it and understanding what is required and then bringing together the elements for its solution; in short, beginning to practice engineering as an intellectual and not merely a routine process.

3 *A Stimulus to Individual Development.* Contemplation of the different characters of the two examinations prompts the question as to one's own progress. It clarifies what President Doherty says in portraying "The Engineering Profession Tomorrow" concerning engineering education: "Intellectual power, not merely routine skills and memorized facts, is the primary end. Acquisition of subject matter without a cultivated method of applying it to practical situations is educational sterility."

As the embryo engineer realizes that knowledge without ability to apply it is also *engineering* sterility, he gains a new viewpoint as to his own development. He may well question whether his environment and efforts are producing the requisite qualities, or whether change is essential to his proper development.

4 *Incentive to "Professional" Consciousness.* The alert recruit will want to know what are the "professional" aspects of the career in which he has enlisted. He finds that much more is involved than he had realized. Not only must he keep abreast with the advances in his own field, which may call for continual study aided by membership in his technical society and recourse to technical journals, but supplementing technical proficiency there are other qualities which distinguish a professional man, such as basic integrity, standards of conduct based on courtesy, honor, and ethics, also a motive for service and a recognition of social duty. These matters now become realistic and personal. A new consciousness is awakened. Then he may come to see that the profession for which he is in training ranks high as an agency in economic progress and social welfare; it challenges his own ideals and efforts.

5 *Collective Bargaining.* Without attempting a discussion in detail, it may be remarked that a certificate from a state board certifying that an important initial step has been taken toward recognition as a professional engineer may have a bearing on the individual's status in collective bargaining. In any event, the possession of the certificate should strengthen the ambition to achieve full professional status.

6 *Aid to Engineers-in-Training.* Registration boards which have had little to do with prospective registrants until formal application for registration is received, may now make known

[1] Dr. Scott died on Dec. 17, 1944. This article, written shortly before his death, was prepared for the Connecticut Technical Council which had been asked for its recommendation as to the adoption of "Engineers-in-Training" in the registration procedure. At the time of his death Dr. Scott was chairman of the Connecticut State Board of Engineering Examiners.—EDITOR.

to those formally enrolled what kind of experience they deem satisfactory and indicate the technical and professional capabilities and attitudes which should be developed in the training period. A definite group with a common goal may be aided in their training by their elder brothers. (Often young engineers who are steering their own career may be working hard but up blind alleys; for example, the immediate task may dominate interest and effort to the exclusion of long-range but less tangible objectives.) In New York (where the movement was initiated by a group of young engineers) an organization of Engineers-in-Training is forming which is sponsored by the State Society of Professional Engineers.

7 *A General Stimulus to Professional Development.* The Engineers-in-Training movement, by emphasizing and fostering after-graduation development as essential to competency in professional engineering, may awaken other agencies to their opportunity and responsibility. While much attention is given to undergraduate curricula and training, far too little is directed to the objectives and methods and aids to maturer growth in the after-graduation period. Engineering societies, national and local, individually and collectively, and industries, individually and collectively, may well determine how to increase their interest and efforts in assisting their younger personnel in wholesome professional development. They do not need elevators to raise them to higher levels, but they do need aid in recognizing and reaching the rungs of the ladder on which they must climb.

8 *Engineering Schools and Registration.* Examination soon after graduation by a state board may not merely appraise technical knowledge but it may be a test of breadth of attainment in engineering method and attitude and other qualities which educators proclaim as objectives of college training—in short, to determine broadly the adequacy of the school training as the foundation for a professional career. Results of the preliminary examination are of vital concern to the engineering teacher as well as to the examining board. If graduates of accredited courses fail in this preliminary test, something is wrong—the accrediting, or the teaching, or the student, or the examination. Fatalities should prompt an inquest. When facts are known, remedies may follow.

Educators will gain new understanding of professional registration; they will inform their students regarding it; they will be alert to prepare their students for it. In short, the preliminary examination should establish close relations between educators and examiners.

9 *Résumé.* Thus the preliminary examination becomes a focal point of many interests in the graduation-to-registration period. *To the bewildered graduate* it is clarifying and directive; he gains perspective on his own career as he finds how experience may build competency; and he is inspired by the greatness of the profession for which he is training. *To examining boards* the separation of preliminary and final examinations explains the difference between the status of candidate at graduation and after the years of experience: What should he gain? What has he gained? And what constitutes fair examinations? Furthermore, there is opportunity and implied responsibility for giving helpful information and suggestion to those admitted to training. *To the engineering teacher* there may come an immediate appraisal of his graduates. He comes in close contact with registration—"the new development in engineering." He realizes his responsibility in building "the engineering profession of tomorrow." Contacts between educators and examiners may lead to mutual understanding and better co-ordination between the two great stages in the development of the engineer. *To engineering societies* and industries there may come a new realization of what they should contribute to the "experience" period in the development of those who are to be their leaders later on. True, they have been doing a good job here and there, but it is spotty. The problem has been treated as local and incidental. But it is universal and vital. Difficulties are challenging in normal times; they are intensified by the war upset. Can they meet the challenge now?

MECHANICAL PROPERTIES *and* USES *of* WOOL FELT

(Continued from page 99)

As a final consideration of the mechanical properties of wool felt, attention is invited to other functional data accumulated on the wear resistance, oil absorption, capillary flow, thermal conductivity, and coefficients of friction and sound absorption of S.A.E. felts. From the composite tabulation of these data, Table 7, the following facts are to be noted:

1 The wear resistance of wool felt is in direct proportion to density and fiber quality, and in inverse proportion to applied load.

2 The coefficient of friction of felt is, for all practical purposes, independent of density or S.A.E. grade but highly dependent upon the texture and smoothness of adjacent surfaces as well as the viscosity of associated lubricating oils.

3 The oil-absorption capacity of the lower-density felts is proportionately greater than that of the higher-density felts as evidenced by a 200 per cent greater retention capacity for S.A.E. F-15 than for S.A.E. F-1.

4 The wicking rate of wool felt is dependent on fiber quality, felt construction, density, and oil or fluid viscosity.

5 The thermal conductivity of wool felt is notably low among insulating materials and decreases with decreased felt density. Combinations of kapok fiber with wool produce lightweight insulating felts of 0.21 "K" factor.

6 The sound-absorption efficiency of felt is dependent on variable factors of fiber blend, felt density and construction, and air permeability. Combinations of kapok fiber with wool produce sound-absorption felts of 0.80 sound-absorption coefficient at 512 cps and 0.70 noise-reduction coefficient for 1 in. thickness.

CONCLUSION

In conclusion, the specifications governing the selection and acceptance of wool felt are well established and serve as a useful guide in reviewing the grades and qualities in which it is available. Commercial forms range from soft felts of a few ounces per square yard weight to yard-square sheets that are 3 in. in thickness, weighing 70 lb per sq yd, and literally "hard as a board."

Mechanical felts are most completely specified by the felt standards of the Society of Automotive Engineers. Government purchases are controlled by U. S. Army Specification 8-15G, "Felt, Pressed;" Navy Department Specification 27F7, "Felt, Wool;" and Army-Navy Aeronautical Specification AN-F-14, "Felt, Wool." Standard specifications of the Felt Association, Inc., embrace 40 numbers in 7 series over a complete range of densities, types, and colors. Reference to these specifications and standards, as well as methods of test approved by the American Society for Testing Materials, "Methods of Test for Wool Felt," A.S.T.M. D461, provide helpful guidance in the selection of this veteran among natural engineering materials.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

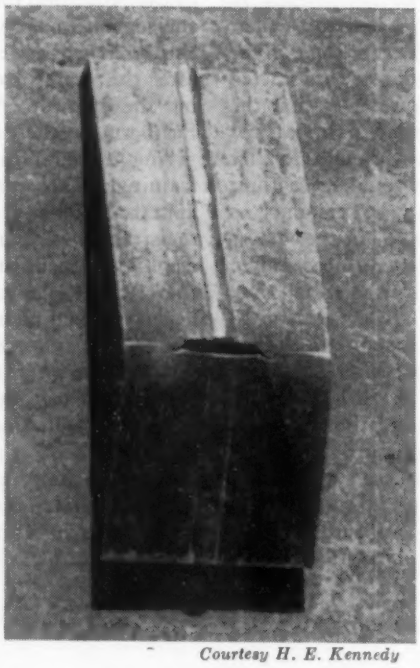
Engineering Is a More Exact Science Than Welding

To the Editor:

On page 614 of the September issue of Mechanical Engineering, Mr. J. F. Lincoln concludes that "perhaps engineering is not an exact science . . . ," apparently because engineers continue to have some suspicions regarding the performance of welded joints. Perhaps the fact that engineers have not accepted all of the claims that have been made for welding is rather good proof that engineering still remains an exact science.

The writer has followed the progress of welding to quite an extent for the past fifteen years, and during the past year and a half he has devoted most of his time to directing a rather extensive research program involving a serious welding problem. He would be among the first to say that there has been too much opposition to welding in many quarters. However, those of us who are concerned with welding should readily admit that there are some things about welding and the performance of welded joints that are not known. Further, there are entirely too many statements made by members of the welding fraternity, in welding publications, and by manufacturers of welding equipment, that are not completely true. They are sometimes true when applied to certain conditions. In many cases this is apparently due to the fact that adequate research was not conducted before the statements were made. It all serves to emphasize the fact that we do not have enough factual data available about the performance of all types of welded structures under all conditions.

There has been a regrettable tendency on the part of the manufacturers of welding equipment to divert the public's attention from the troubles and failures that accompany welding and give the impression that no difficulties exist. An excellent example of a statement which does just this is found where Mr. Lincoln states "the metal in the welded joint has an elastic limit in excess of 50,000 psi. Mild-steel plate as rolled has an elastic limit under 40,000 psi. Hence any stress of a welded structure which will stretch the plate will not affect the welded joint . . . ." This appears to be a most assuring statement. But let us look at some experimental evidence to see if the situation is as happy as pictured.



Courtesy H. E. Kennedy

FIG. 1 WELDED TEST SPECIMEN SHOWING INITIAL FAILURE IN THE WELD

In Fig. 1 is shown a test specimen which was a low-carbon-steel plate of A.B.S. ship quality $^3/_4$ in. thick and 4 in. wide. A weld bead was deposited on one side of the plate as shown. A nick was made in the weld bead. The specimen was then supported as a simple beam, with the weld bead on the supported side, and loaded at —20 F. As can be seen in the photograph, the weld and the region immediately adjacent to it broke while the remainder of the plate remained intact. Several of these specimens have been tested with similar results. After the initial fracture of the weld occurred, the remainder of the plate carried considerably increased load in spite of the reduced area. These specimens are obvious contradictions of Mr. Lincoln's reassuring statement. In ordinary tension tests his statement would be essentially true. But many welded structures are loaded in bending and subjected to low temperatures.

As Mr. Lincoln states, if X-ray inspection reveals defects they can be chipped out and rewelded. But the ratio of welds which are not X-rayed to those that are is extremely large. Furthermore, if a weld is chipped out and rewelded, a condition of high residual stress results, the effect of which is not fully known. Likewise, his comparing the voids in a weld with those in a riveted joint is not satisfactory. The weld defect is a more serious notch and is in a rigid and continuous structure while the voids in a riveted joint are in a discontinuous and relatively flexible structure.

Welding possesses such outstanding advantages that every fair-minded engineer wants to use it as much as possible. It is used daily in thousands of applications with entire success. However, there are many other applications where no one can predict how the resulting structure will perform. The difficulties are undoubtedly not due to the quality of the weld deposit. But something connected with the fact that the structure is welded is the cause. Obviously welding should not be used where the results are not predictable without including a sizable factor for the ignorance which exists. Those who want to promote the use of welding can aid materially by fostering sound unbiased research so as to make welding design a science. The availability of factual information will do more than sales propaganda to change the attitude of engineers. Welding as well as engineering should be an exact science.

E. Paul DeGarmo.[1]

To the Editor:

Mr. DeGarmo, in his article "Engineering Is a More Exact Science Than Welding," criticizes my letter which was published in the September issue of Mechanical Engineering.

It would seem to me that Mr. DeGarmo has missed the point that I made which is that a welded joint is stronger in every direction than is a riveted joint. That is true.

There has never been any claim made by myself that every weld is perfect. The claim, however, can be justly made that welds, as an average, are much more

[1] Associate Professor of Mechanical Engineering, University of California. Mem. A.S.M.E.

nearly perfect than the steel that they weld together and are also stronger than any riveted joint.

It is perhaps well to cite that from the beginning of welding history to the present time there has never been a failure of an insured welded joint. I say "insured" because on these only is there complete history as to their action and record.

It would seem to me that it would be well for engineers to discuss the utility of this relatively new process of welding and encourage its economies which have been so decisive in this present war effort, rather than to continually drag their feet.

J. F. LINCOLN.[2]

[2] President, The Lincoln Electric Company, Cleveland, Ohio. Mem. A.S.M.E.

Interprofessional Institute

TO THE EDITOR:

I have read with interest Mr. Spector's letter published in the October issue of MECHANICAL ENGINEERING, in which he suggests an interprofessional organization for the exchange of information between the members of the various learned professions. Mr. Spector's proposal was anticipated over twenty years ago by Mr. Thomas Kimball, then president of the American Institute of Architects, who with others founded the American Interprofessional Institute, whose aims and purposes are those outlined by Mr. Spector.

The Institute has Chapters in many Midwestern cities. The Milwaukee Chapter, to which I have belonged since its inception, has among its members leading men of all the learned professions, including many engineers.

We have weekly luncheon meetings which are well attended and which are usually addressed by one of our members, the addresses and following discussion being very stimulating to members of other professions than that of the speaker.

As a result of my own experience I thoroughly agree with Mr. Spector that such interprofessional groups should be formed throughout the country and that engineers should take an active part therein.

I shall be glad to give further information on this subject to anyone interested.

ARTHUR SIMON.[3]

[3] Patent attorney and engineering consultant, Milwaukee, Wis. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Boiler Code Committee to all of its members. The interpretation, in the form of a reply, is prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval and then issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations formulated at the meeting of November 17, 1944, and approved by the Council on December 22, 1944.

ANNULLED CASES

Case Number	Paragraph Revised
974	Pars. P-278, P-332(e)
979	Alternate Rules for Unfired Pressure Vessels
988	Deletion of Specification S-4
991	Preamble, Pars. P-301, P-332(e)
1001	Par. P-112(c)
1003	Par. P-290(a)
1005	Par. P-112(c)
1006	Par. P-102(h)
1007	Pars. P-198(a)

CASE No. 828 (Reopened)

(Special Ruling)

Inquiry: Is it permissible, under the rules of Section VIII of the Code, to construct fusion-welded vessels of nickel-clad steel plate?

Reply: It is the opinion of the Committee that unfired pressure vessels may be constructed of nickel-clad plates complying with Specification SA-265 provided that all Code requirements covering design, welding, and tests for the class of service for which the vessels are intended are complied with, as well as the following additional requirements:

(1) The provisions of this Case are limited to the use of nickel-clad steel plate material specified in Specification SA-265.

(2) The base plate material shall be in accordance with an approved steel plate specification, the required tests being made of specimens with the clad material removed. The bend test shall be made with the clad side in tension.

(3) All nickel-clad plates shall show a minimum shear test of 20,000 psi when tested in the manner described in the specification. One shear test shall be made on each rolled plate and results reported by the mill.

(4) The full thickness of the composite plate may be used in design calculations for Par. U-68 vessels provided the service temperature does not exceed 250 F, and for other vessels provided that both the service temperature does not exceed 250 F and the service pressure does not exceed 100 lb. For all other vessels the thickness of the carbon steel base plate only shall be used in design calculations. Allowable stresses shall not exceed those given in Table U-2 for the base materials used.

(5) When the full thickness is used for design calculations or when the joint is to be made without first removing a narrow strip of cladding, the welding procedure qualification tests, the welding operator qualification tests, and the production test plates of Par. U-68 vessels shall include two free-bend specimens, one of which shall be tested with the cladding in tension and the other in compression; both shall meet the elongation requirement, measured over a gage length of not less than $1/_2$ in. including the weld, for the class of construction required.

(6) The weld shall be completed before radiographing where radiographing is required except that when the thickness of the carbon steel base plate only is used in the design calculations and the joint is made by first removing a narrow strip of the nickelcladding, then welding the base plate and subsequently inserting a strip of nickel welded along both edges to restore the cladding, the weld in the base plate may be radiographed before the cladding is restored.

(7) The types of joint and welding procedure used shall be such that steel weld metal shall not fuse into the nickel layer and the depth of the nickel bead shall be kept to a minimum.

(8) No fillet weld shall be allowed in longitudinal or girth joints except for

dished heads of Par. U-70 vessels convex to pressure (See Fig. U-18c).

It is important that the completed welds have a corrosion-resistant property substantially equal to that of the nickel cladding. Until such time as suitable rules to test corrosion-resistant properties of welds are formulated, the manufacturer should satisfy the purchaser that the weld is suitable for the intended vessel use. For operating temperatures in excess of 250 F, consideration should be given in the design of the vessel to the effect of thermal stresses arising from the difference in coefficients of expansion of the two materials.

CASE No. 855

(Annulled)

CASE No. 896 (Reopened)

(Special Ruling)

Inquiry: Is it permissible, under the rules of Section VIII of the Code, to construct fusion-welded pressure vessels of alloy clad plate material complying with Specifications SA-263 and SA-264?

Reply: It is the opinion of the Committee that fusion-welded pressure vessels may be constructed of alloy-clad plate material complying with the above specifications provided that all requirements in Section VIII covering design, welding, and tests for the class of service for which the vessels are intended are complied with, as well as the following additional requirements:

(1) It is expected that vessels of alloy steel clad plate covered by these rules will be used to hold liquids and gases corrosive to ordinary materials, but the selection of an alloy suitable for the vessel's contents and the determination of corrosive allowances is not covered by these rules.

It is recommended that users assure themselves by appropriate tests, or otherwise, that the alloy selected and its heat-treatment following fabrication are suitable for the service intended.

Where service data are not available, the procedure of Par. U-11(b) shall be followed.

(2) The chemical composition of the base plate material shall be in accordance with an approved plate-steel specification.

(3) All alloy steel clad plates shall show a minimum shear test of 20,000 psi when tested in the manner described in the specification. One shear test shall be made on each rolled plate and results reported by the mill.

(4) When the full thickness is used for design calculations, or when the joint is to be made without first removing a narrow strip of cladding, the welding procedure, operator qualification, and vessel test plates shall include duplicate bend specimens, one with the alloy surface in tension and the other with the alloy surface in compression, both of which shall meet the elongation requirements of the class of construction (Pars. U-68, U-69, or U-70) involved, with the elongation measured over a gage length of not less than $1/2$ in. including the weld.

The all-weld metal tension bar required by Par. U-68(d) shall contain no stainless alloy on the gage length. Where not enough carbon steel weld metal is available for the standard 0.505 bar, it may be omitted.

(5) Vessels constructed of type 430 composite material shall be limited to a service temperature of 800 F. In no case shall the service temperature for vessels constructed of composite materials exceed the limiting temperature given in Table U-2 for either the backing or facing material used.

Stress relief shall be mandatory for vessels constructed of chromium steel clad material.

Because of the danger of cracking when welding composite plates of chromium steel clad material with straight chromium steel rods, X-ray examination of all main seam welds is mandatory for Pars. U-68 and U-69 vessels, while the completed alloy welds for Par. U-70 vessels shall be carefully examined for cracks. Where austenitic rods are used on chromium steel clad material for Pars. U-69 and U-70 vessels, radiographing of the welds is not required.

(6) The types of joints and welding procedure used shall be such that steel weld metal shall not fuse into the stainless layer and the depth of the stainless bead shall be kept to a minimum.

(7) The full thickness of the composite plate may be used in design calculations for all classes of construction where corrosion is not expected.

The allowable stress shall not exceed the values given in Table U-2 for the grade of steel used for the base material.

(8) Where corrosion of the liner material is expected, additional metal thickness should be provided. In such cases the thickness added for corrosion shall be removed from the alloy face of all tensile bars before testing.

CASE No. 1014

(Interpretation of Par. P-115)

Inquiry: Will the attachment of a furnace to the front tube sheet of a Scotch type boiler meet the Code requirements if the construction and provisions of Par. P-115 are used?

Reply: It is the opinion of the Committee that the intent of the Code will be met provided that:

(1) The tube sheet is supported by tubes, or braces, or both;

(2) The joint is wholly outside the furnace;

(3) The furnace at the weld is not in contact with primary furnace gases;

(4) The throat of the full fillet weld is equal to 0.7 of the thickness of the head;

(5) The construction conforms in all other respects to Code requirements including welding, stress-relieving, etc., except that radiographing is not required;

(6) The construction is not used on the rear head of a Scotch-type boiler.

CASE No. 1017

(Special Ruling)

Inquiry: May the detail for fusion welding shown in Fig. 42 be used to attach a ring type flange to the shell, head, or large nozzle neck of an unfired pressure vessel?

Reply: It is the opinion of the Committee that the flange attachment detail shown in Fig. 42 meets the intent of the

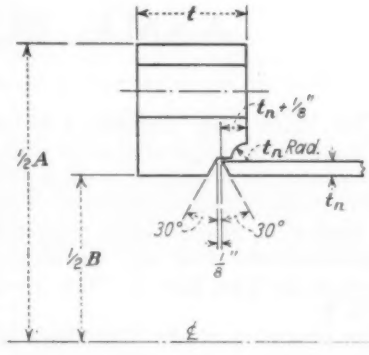


FIG. 42 FUSION WELDED CONNECTION FOR A RING FLANGE

Code and may be used in Code constructions provided:

(1) The welding details at the back of the ring flange are at least equal to those shown for detail 7(a) of Fig. UA-3, and that the inside weld be made with surfaces prepared with an included angle of not less than 60 deg;

(2) The flange ring is designed as a loose-type ring flange within the limitations established in Par. UA-21(a)(1);

(3) The flange ring, if cut from plate material, is free of serious laminations.

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph number to identify their location in the various sections of the code and are submitted for criticism and approval from anyone interested therein.

It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added word are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-7. Revise the first sentence to read:

Staybolts shall be of iron COMPLYING WITH SPECIFICATIONS SA-84, or OF steel [of the quality designated in] COMPLYING WITH Specification SA-81 [or SA-84] OR OF ANNEALED MONEL METAL COMPLYING WITH SPECIFICATION SB-164.

TABLE P-9. Add the following as (*f*):

Stresses, psi	For lengths between supports not exceeding 120 diameters
(*f*) Threaded rigid Monel metal staybolt (annealed) (SB-164)	9500

PAR. P-20. Revise to read:

P-20 (**a**) EXCEPT AS NOTED IN (**b**), the minimum thicknesses of tube sheets for fire-tube boilers shall be as follows:

(same table as in present paragraph)

(**b**) TUBE SHEETS WITH A STRAIGHT FLANGE LONGER THAN $1\frac{1}{2}$ TIMES THE TUBE SHEET THICKNESS, WHEN BUTT-WELDED TO THE SHELL OF A FIRE-TUBE BOILER, SHALL HAVE A MINIMUM THICKNESS AS SPECIFIED IN (**a**) BUT WHICH IN NO CASE SHALL BE LESS THAN 0.75 TIMES THE REQUIRED SHELL THICKNESS, BASED ON THE MAXIMUM ALLOWABLE WORKING PRESSURE.

PAR. P-108 (**b**). Revise to read:

(*b*) All connections attached by fusion welding shall be stress-relieved, EXCEPT AS ALLOWED OTHERWISE IN PAR. P-268(**p**).

PAR. P-186(**c**). Add the following as the second section:

Mud rings of plate material permissible under the Code may be used in the construction of waterlegs of vertical fire-tube boilers and may be attached as shown in Fig. P-21(**f**) in compliance with the requirements of Par. P-198, provided:

(1) The width of the waterleg does not exceed 4 in.;

(2) The thickness of the mud ring plate is at least $\frac{1}{2}$ in.

The welding shall be stress-relieved, but radiographic examination is not required.

PAR. P-268(**p**). Revise as follows:

(**p**) UNLESS SPECIFICALLY ALLOWED OTHERWISE, all connections after being attached by fusion welding shall be stress-relieved.

FUSION-WELDED CONNECTIONS MAY BE ADDED TO A VESSEL AFTER IT HAS BEEN STRESS-RELIEVED, WITHOUT REQUIRING STRESS-RELIEF PROVIDED:

(1) THE DIAMETER OF THE ATTACHMENT OPENING IN THE VESSEL WALL DOES NOT EXCEED THAT ALLOWED FOR AN UNREINFORCED OPENING; OR DOES NOT EXCEED 2 IN., WHICHEVER IS SMALLER;

(2) THE INSIDE AND OUTSIDE ATTACHMENT WELDS DO NOT EXCEED $\frac{3}{8}$ IN. THROAT DIMENSION.

THIS PROVISION DOES NOT APPLY TO THOSE CONNECTIONS SO PLACED AS TO FORM LIGAMENTS IN THE SHELL, THE EFFICIENCY OF WHICH WILL AFFECT THE SHELL THICKNESS. SUCH ADDED CONNECTIONS SHALL BE STRESS-RELIEVED.

PAR. A-45. Revise the second sentence of the first section to read:

The remaining valves may be set within a range of 3 per cent above the maximum allowable working pressure, but the range of setting of all of the SATURATED STEAM valves on a boiler shall not exceed 10 per cent of the highest pressure to which any SATURATED STEAM valve is set.

PARS. L-102(**h**) SECOND SENTENCE OF SECOND PARAGRAPH AND U-68 (**b**) (**2**) SECOND SENTENCE. Revise to read:

THE WELD RIPPLES OR WELD SURFACE IRREGULARITIES, ON BOTH THE INSIDE AND OUTSIDE, SHALL BE REMOVED BY ANY SUITABLE MECHANICAL PROCESS, TO A DEGREE SUCH THAT THE RESULTING RADIOGRAPHIC CONTRAST DUE TO ANY REMAINING IRREGULARITIES CANNOT MASK OR BE CONFUSED WITH THAT OF ANY OBJECTIONABLE DEFECT. ALSO THE WELD SURFACE SHALL MERGE SMOOTHLY INTO THE PLATE SURFACE. [The weld reinforcements on both the inside and outside shall be ground, chipped and ground, or suitably machined to remove the irregularities of the weld surface so that it merges smoothly into the plate surface.]

PAR. H-39. Add the following: as a footnote to the table:

For systems with more than 2400 sq ft of installed equivalent direct water radiation, the required capacity of the cushion tank shall be increased on the basis of one gallon tank capacity per 33 sq ft of additional equivalent direct radiation.

PAR. U-59(**p**). Add to the first section and to the first sentence of the second section the words, "except as allowed otherwise in this paragraph;" add as the third section, the same as is being added to Par. P-268(**p**).

PAR. U-70. Add the following as (**f**):

(**f**) Vessels assembled in the field shall not be built under the requirements of Par. U-70.

PAR. U-208(**c**). Revise the second section to read:

[Cylindrical specimens or those not having a plane surface shall be sectioned across the welds to obtain plane surfaces which shall include the full width of the weld. The plane surfaces shall be polished to a bright, smooth condition which may be accomplished by filing or grinding and polishing with emory cloth and should be completed with the use of emery cloth of grade 00.] The specimens shall [then] be GROUND OR OTHERWISE SMOOTHED AND THEN etched by any method or solution which will reveal the defects without unduly exaggerating or enlarging them (See Par. UA-85).

PLANE-LAUNCHING GUN TESTED

(Workman at the U. S. Naval Ordnance Plant, Canton, operated by the Westinghouse Electric & Manufacturing Company, shoves a shell into a plane-launching catapult gun to test the breech, the hinged metal door that seals the shell in the gun. This gun will provide the power to launch scouting planes from the deck of a battleship or a cruiser. When a shell containing black powder is fired in the gun, the rapidly expanding gases rush into a bomb-shaped expansion chamber and then operate a large piston, just as gasoline vapors explode to push the piston in an automobile engine. The piston yanks a small cart along the catapult track and the plane, sitting on the cart, is tossed into the air.)

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

The Elements of Administration

THE ELEMENTS OF ADMINISTRATION. By L. Urwick. Harper & Brothers, New York, N. Y., 1944. Cloth, 5¼ × 8 in., 132 pp., 5 figs., $2.

REVIEWED BY J. M. JURAN[1]

THIS is a distinguished book by a distinguished scholar. Concentrated to a degree approaching terseness, studded with quotable epigrams, and incisive to the point of taxing the attention, "The Elements of Administration" may properly be characterized as the most penetrating beam thus far trained on the fog that is the art of administration.

Mr. Urwick has scored most heavily in two of the most difficult concepts in administration: the orderly division of the subject into its constituent parts and the effective co-ordination of these constituent parts one with another. Here Mr. Urwick is at his best with precise definitions, lucid explanations, and illuminating asides. However, the fact that the terminology is British, not American, constitutes an obstacle to the American reader as well as posing a problem in standardization of terminology within the so-called "English" language.

Another noteworthy achievement is that the diction itself commands respect. Mr. Urwick approaches Mr. Churchill in his uncanny ability to sort adjectives and to choose those which have the correct weight and the most appropriate tint. The over-all result is a masterpiece of balanced emphasis and restraint.

Notwithstanding Mr. Urwick's excellent performance, his short-term audience may well be limited. A better book on differential equations is still beyond the scope of those who have not mastered calculus. Mr. Urwick's salient likewise starts from an advanced base.

Moreover, Mr. Urwick deals with administration in its broad (and correct) sense. He speaks of incentive in its broad (and correct) sense. But the advanced practitioners in administration are largely to be found in industry, and the experience of these men is largely limited to industry. There may well be doubt that Mr. Urwick's broader definitions, which embrace government, the military, and many other establishments, as well as industry, will strike responsive chords in such an audience. Yet even if this doubt is well founded, it does not deny the validity of Mr. Urwick's statements of principles. Rather it provides a contrast between the most forward point of Mr. Urwick's salient and the pace at which practical application is proceeding toward that point. There are those who might question the need for advancing the outposts so far beyond the boundaries of our existing practice. Yet this has always been the right of the explorer, and history bears him out.

But whatever may be said about the size of the audience presently qualified to appreciate "The Elements of Administration," the book is of a distinctly enduring caliber. Its value will increase as the level of appreciation of the nature and importance of administration rises. And rise it must. At no time in recorded history has human organization grown so rapidly to such formidable size. Big industry, big government, big labor unions, big production, big distribution, big social problems, big international problems—these and other organizational giants are stalking all about us in various states of disorganization. Our ability to control these giants is in proportion to our knowledge and practice of sound administration. True, our methods of solution are developing also, but we may well ponder whether we are winning or losing this race.

[1] Assistant Administrator, Foreign Economic Administration, Washington, D. C. Mem. A.S.M.E.

Enough and to Spare

ENOUGH AND TO SPARE. By Kirtley F. Mather. Harper & Brothers, New York, N. Y., 1944. Cloth, 4½ × 7½ in., 186 pp., $2.

REVIEWED BY E. G. BAILEY[2]

THIS book is a pleasing surprise in that it not only covers rather broadly the geological resources of the world, the renewable resources from farm and forest, trends and probable future maximum population, but also in the last three chapters, the author expounds very creditably on systems of government, intellectual needs for democracy, and plans for our future.

The headings for the chapters are different from those just indicated, which, as well as the title of the book, inadequately disclose the real contents to such a degree that many might not be tempted to read the book unless they learn that they camouflage many real gems in a scientific approach to many important problems which face each one of us and which are convincingly substantiated by philosophic and religious reasoning.

Even those who are not especially interested in our economic resources and economics would do well to begin by reading chapters 5, 6, and 7, from which they may learn much about our individual obligations to society. The author stresses that each individual has his duties and obligations to perform in our politico-economic society; he is more optimistic for the immediate future than for the distant future, not because of limitations in physical resources so much as in intellectual and moral progress.

One who begins the book by reading chapters 5, 6, and 7 might next read chapters 1, 3, and 4, leaving chapter 2 to the last, or omitting it and the appendix altogether, if one is not particularly interested in the statistics of our resources and consumption of coal, petroleum, iron ore, and other minerals.

The author quotes authoritative data on rates of consumption and on estimated reserves of resources. Recognizing that the reserves of some of our mineral resources are little better than educated guesses, he takes the optimistic side regarding the supply of petroleum, the making of motor fuel from coal and shale, without even suggesting that increased costs may influence our future economic relation between man-hours actually required to attain a desired standard of living. The author also says there is plenty of iron ore, much of which is of a definitely lower grade than that now being used, leaving the question of relative costs to decide whether we increase our imports of high-grade ores from Cuba and Brazil or use our lower grades, but giving no advice or prophecy regarding the question of whether technological development can continue to progress fast enough to offset the problem of

[2] Vice-president, The Babcock & Wilcox Co., New York, N. Y. Fellow A.S.M.E.

producing all the iron we want from lower and lower grades of iron ore and coal, with decreasing working hours at higher rates.

Data on hydropower are given with the intimation that we might well afford to develop it to its full extent and transmit it over great distances "at relatively low cost." This, too, is on the optimistic side of present economics. The possibility of power from tides, wind, and sun are mentioned briefly but with an implied assurance that seems entirely unwarranted from known history, thermodynamics, and probable future economics.

The author has given an extensive bibliography and a list of references on the subjects related to the broad range covered in this book "Enough and to Spare."

Books Received in Library

AIRPORT ENGINEERING. By H. O. Sharp, G. R. Shaw, and J. A. Dunlop. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1944. Cloth, $8\frac{1}{2} \times 11\frac{1}{4}$ in., 150 pp., illus., diagrams, charts, tables, $5. This undergraduate textbook presents concisely the problems that confront the airport builder. After a brief discussion of airport size and site, planning and preliminary surveys are considered. Problems of grading, drainage, soil stabilization, and paving are then treated. Finally, lighting, buildings, and construction and maintenance equipment are presented.

AMATEUR TELESCOPE MAKING, edited by A. G. Ingalls and others. 497 pp., $4.

AMATEUR TELESCOPE MAKING ADVANCED, a sequel to "Amateur Telescope Making," edited by A. G. Ingalls. 650 pp., $5. Munn and Co., New York, N. Y., 1943–1944. Cloth, $5\frac{3}{4} \times 8$ in., illus., diagrams, charts, tables. A comprehensive detailed account of the parts and operations necessary for the construction of telescopes is presented in this two-volume set. Volume 1 discusses types, lenses, mirrors, mountings, drives, etc., and provides some 200 pages of practical information on a large number of technical details. Volume 2 offers a more advanced description of the finer work needed to produce superior instruments and also covers the practical aspects of observing. There is a twenty-page annotated bibliography in the first volume.

BULLDOZERS COME FIRST, the Story of U. S. War Construction in Foreign Lands. By W. G. Bowman, H. W. Richardson, N. A. Bowers, E. J. Cleary, and A. N. Carter. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Cloth, $5\frac{3}{4} \times 9$ in., 278 pp., illus., maps, $2.75. An interesting series of articles describing the work of American engineers overseas during the present war, as seen by war-corresponding editors of the *Engineering News-Record*, in which the articles first appeared. Great Britain, North Africa, the Middle East, Alaska, the Aleutians, the Pacific Ocean areas, South America, and Central America were visited.

DYNAMICS OF TIME STUDY. By R. Presgrave. University of Toronto Press, distributed by Ambassador Books, Ltd., Toronto, Canada, 1944. Cloth, $6 \times 9\frac{1}{4}$ in., 211 pp., diagrams, tables, $3.50. The author analyzes the essential principles to which sound time-study technique must conform in order to function effectively. He points out many elements which are unnecessary or are actual drawbacks in time-study work. The primary design of the book is to help those now engaged in time study to assess their present methods, to modify them out of reason rather than out of experience, and so to use them with greater confidence.

COMFORTIZATION OF AIRCRAFT. By A. A. Arnhym. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1944. Cloth, $6 \times 9\frac{1}{4}$ in., 347 pp., illus., diagrams, charts, tables, $7.50. Looking to the future, designers and others associated with the airplane industry and air transport are concerned with passenger comfort and conveyance. The author has assembled technical data, calculations, information, and illustrations useful in eliminating discomforts inherent to flying. He outlines the various important phases and gives a detailed analysis of air supply, heat supply, soundproofing, seating, berthing, and catering. Procedures and methods are included for incorporating, specifying, selecting, and servicing comfort equipment.

GENERAL METEOROLOGY, published formerly under the title, "Synoptic and Aeronautical Meteorology." By H. R. Byers. McGraw-Hill Book Co., Inc., New York., N. Y. and London, England, 1944. Cloth, $5\frac{1}{2} \times 9$ in., 645 pp., illus., diagrams, charts, maps, tables, $5. This book is designed as a general text embodying the fundamentals as well as the modern development in synoptic meteorology, including recent advances in the field such as isentropic analysis, new forecasting uses of upper-air pressure charts, etc. The last five chapters of the book cover material of particular importance in aeronautics. An appendix contains practical aids for the student and meteorologist.

MANUAL OF MACHINE SHOP PRACTICE. By O. Benedict, Jr. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Fabrikoid, $4\frac{3}{4} \times 7\frac{1}{2}$ in., 249 pp., illus., diagrams, charts, tables, $1.75. The main part of this small book is devoted to such aspects of machine-shop practice as cutting speeds and times, screw-thread production, the spiral head for milling machines, tolerances and allowances, precision measuring devices, press tools, and machine-tool analysis. Ten illustrative experiments for various operations are included, and a considerable amount of technical data is provided in an appendix.

NOTES ON HELICOPTER DESIGN THEORY. By A. A. Nikolsky. Princeton University Press, Princeton, N. J., 1944. Paper, 6×9 in., 228 pp., diagrams, charts, tables, $3. This volume presents a series of lectures given at Princeton University in the spring of 1944 to a group of engineers representing the Army and Navy air forces and various aircraft manufacturers. The treatment is theoretical and, mathematical and, of necessity, tentative, as theory in this field is still in an unstable state.

PAPER AND PAPERBOARD, Characteristics, Nomenclature, and Significance of Tests. October, 1944, sponsored by A.S.T.M. Committee D-6 on Paper and Paper Products, American Society for Testing Materials, Philadelphia, Pa., 1944. Paper, 6×9 in., 108 pp., illus., charts, tables, $1.50. The four parts of this report cover respectively: general considerations and the nature of paper properties; the action of water on paper and its significance; definition of terms, nomenclature, and properties of various classes of paper and paperboard; and a discussion of commonly used tests applied to paper and paperboards and their significance. A complete list of A.S.T.M. and TAPPI test methods is included.

PLASTICS STOCK MOLDS, Catalog of Stock Molded Parts, Extrusions and Laminates; compiled by Stock Mold Department of *Modern Plastics* magazine, New York, N. Y., 1944. Cardboard spiral binding, 8×10 in., 168 pp., illus., $5. Nearly 1600 current stock injection and compression molds for plastics are illustrated in this Catalog, classified under twenty-two headings according to type of product. By reference to a list of item numbers the company owning any mold may be found. This revised edition also provides the same service for some 200 standardized extruded cross sections and laminated sheets, rods, and tubes.

STEAMBOATS COME TRUE, American Inventors in Action. By J. T. Flexner. The Viking Press, New York, N. Y., 1944. Cloth, $5\frac{1}{2} \times 8\frac{1}{2}$ in., 406 pp., illus., diagrams, $3.50. An interesting, well-written account of the early history of the steamboat. The stories of Fitch, Fulton, and Rumsey are told. Fitch's life is described with some fullness, and the reasons for his failure explained. Fulton is given credit as the "inventor," the man who finally won the race. There is a good bibliography.

UNIVERSE AROUND US. By Sir J. Jeans. Fourth edition, revised and reset. University Press, Cambridge, England; The Macmillan Co., New York, N. Y., 1944. Cloth, $5\frac{1}{2} \times 8\frac{1}{2}$ in., 297 pp., illus., diagrams, charts, tables, $3.75. This book contains a brief account, written in simple language, of the methods and results of modern astronomical research, both observational and theoretical. Special attention has been given to problems of cosmogony and evolution and to the general structure of the universe. This fourth edition has been largely rewritten in the light of recent advances, such as the application of the physics of atomic nuclei to various stellar phenomena.

USES AND APPLICATIONS OF CHEMICALS AND RELATED MATERIALS, vol. 2. By T. C. Gregory. Reinhold Publishing Corporation, New York, N. Y., 1944. Cloth, $6 \times 9\frac{1}{4}$ in., 459 pp., $9. This compilation is intended for sellers, users, and makers of chemicals and related materials. It lists some 2600 such substances and tells their uses in detail. It also lists them by uses. Patents which control certain uses of various chemicals are listed and the addresses of patent owners given. There is an index of synonyms. The book supplements the first volume, issued in 1939, and the indexes of uses and patents cover both volumes.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Plans for A.S.M.E. Spring Meeting at Boston, April 16–18, Being Developed

THE 1945 Spring Meeting of the Society is scheduled to be held at the Hotel Statler, Boston, Mass., April 16–18, 1945. The program is beingdeveloped entirely from the point of view of contributing to increased production of war material. The subjects under discussion and the method of operation of the Meeting will, it is believed, conform to the desires of the government that meetings shall contribute definitely to war production. About a dozen divisions and technical committees are contributing sixteen to eighteen sessions. Complete information is not yet available regarding all of these sessions. However, it can now be said that there will be sessions on Aviation, Heat Transfer, Metals Engineering, Textiles, Metal Cutting, and Steam Power.

Fuels Division Sponsors Two Sessions

The Fuels Division will have two sessions which have been fully developed as follows:

Session 1, "Flow of Coal," by Wolfe and von Hohenleiten; and "Elimination of Smoke on Locomotives by the Use of Overfired Air Jets," by E. D. Benton and R. B. Engdahl.

Session 2, "Estimating and Evaluating Army Fuel Consumption," by Richard E. Biller, War Department, Washington, D. C.; and "Pressure Combustion," by Irvin D. Groak.

Training for Leadership

The Committee on Education and Training will have two sessions and a luncheon dealing with the important subject of training for leadership. One paper on this subject will be presented by D. C. Prince, of the General Electric Company, and another on training for leadership as applied to the Ordnance Department will be presented by Brigadier General H. R. Kutz and Col. Bradley Dewey, president, Dewey and Almy, Cambridge, Mass.

Labor Problems to Be Aired

The Management Division is co-operating in the second session at which speakers of national prominence will be heard. Prof. Sumner Schlichter, of Harvard University, will speak on "Industry-Wide Collective Bargaining." "Guaranteed Annual Wages" will be the title of a paper by Ernest Dale, research department of the American Management Association; John Connolly, head of Workers Education Bureau, American Federation of Labor; and Lawrence Rogin, educational director, Textile Workers' Union of America.

Other Management Sessions

A second session of the Management Division will be devoted to a discussion or Ordnance arsenal management. It is planned to present two subjects: Ordnance arsenal planning, and Ordnance arsenal performance measurement.

At the third session the sujbect will be workers' education program, and a paper, "Organized Labor Goes to College," will be presented.

Aviation Division Has Two Sessions

Two sessions are planned by the Aviation Division. At one of these the papers will deal with gas turbines and jet-propulsion engines. At the second a paper on the remote control of turrets such as those used in the B-29 will be coupled with one on water injection in a spark-ignition engine. The authors of the latter paper are W. P. Green and C. A. Shreeve, of the University of Maryland.

Hunt and Uehling, 50-Year A.S.M.E. Members, Send Greetings

AMONG the A.S.M.E. members who were unable to be present at the Annual Meeting of the Society November 27–December 1, 1944, to receive their special Fifty-Year Membership buttons were William F. Hunt and Edward A. Uehling. The former member has expressed his feelings on this occasion in the following telegram received by the Society:

When one's memory recalls the many inspirational friendships of The American Socirty of Mechanical Engineers, Doctor Thurston, Uncle John Fritz, Professor Sweet, Charles Steinmetz, Holley, Warner, Swasey, Harkness, and a host of others, and in loving memory of Charles Wallace Hunt, one can but regret as do I the inability to be present at this dinner to receive the special pin, but I do voice my conviction that our younger members will carry on and be in the forefront of the coming battle for peace, for the real battle is to create not only the necessary material and its distributions but also to create a moral and spiritual leadership which the world so sorely needs.

(Signed) WILLIAM F. HUNT.

Mr. Uehling, who was born in 1849, and who writes from his home in West Allis, Wis., that he is the oldest living alumnus of Stevens Institute of Technology, expressed his feelings in an essay entitled, "How I Feel to Be Ninety-Five Years Old," which he too sent to the Society. He writes in part:

Mentally, I feel happy that my old think tank, although slowed down considerably, still functions normally, which enables me to continue my hobby, which is to correspond with all those of my numerous relations and a few friends who answer my letters. I also write short essays on various subjects and have them typed. I write these essays: First, because the thoughts occur to me; second, because I have the time to write them down; and third, to keep my old think tank from rusting up. . . . .

Vocationally, I have much to be thankful for and little to regret. I happened to be in a position to solve two vital engineering problems: First, the invention of a machine to economically handle the molten iron produced in the modern blast furnace; and second, the invention of an instrument to correctly measure and record temperatures up to and over 2000 degrees. Because of these and several minor accomplishments, my alma mater, Stevens Institute of Technology, conferred upon me the honorary degree of Doctor of Engineering. . . . .

Some of the readers of this letter may want to ask, "What did you do to preserve your physical and mental vigor as well as you have?" The answer to that question is, not what I did but what I succeeded in not doing. The most important attributes to longevity are a strong constitution and an unexcitable temperament. . . . If you want to live long, don't worry . . . "Don't bid the devil good morning before he comes." . . . Do all things in moderation. . . But, above all, do not worry. That's how I feel at ninety-five years old.

Submit Manuscripts Early for Meeting of Applied Mechanics Division

THE Applied Mechanics Division of The American Society of Mechanical Engineers is now making plans for its national meeting to be held in Buffalo, N. Y., May 18 and 19, with headquarters at the Hotel Statler.

Those intending to submit papers for presentation at this meeting are requested to do so as soon as possible in view of the early date for which it is scheduled.

Ricardo Awarded Rumford Medal

IT has been announced by the Royal Society that the Rumford Medal will be presented to Dr. H. R. Ricardo, president of The Institution of Mechanical Engineers and honorary member of The American Society of Mechanical Engineers.

The award is made every second year "to the author of the most important discovery or

useful improvement which shall have been made known to the public in any part of Europe during the preceding two years on heat or on light, the preference always being given to such discoveries as, in the opinion of the President and the Council of the Royal Society, tend most to promote the good of mankind."

E. R. Fish Honored by A.S.M.E. Boiler Code Committee

AFTER 26 years of service on the A.S.M.E. Boiler Code Committee, during the last three of which he was chairman of the Committee, E. R. Fish retired late in 1944 and was elected an honorary member of the Committee.

Mr. Fish, who was engineering consultant of the Hartford Steam Boiler Inspection and Insurance Company of Hartford, Conn., was a manager of the Society from 1923 to 1926, and vice-president from 1926 to 1928. He became a member of the Society in 1914 and was made a fellow in 1936.

E. R. FISH

Resolutions of Boiler Code Committee

Upon the retirement of Mr. Fish as a member of and chairman of the Boiler Code Committee, the following statement and resolution was entered upon the Committee's minutes.

"We all enjoyed having Mr. Fish as a member of the Committee and honored and respected him as our Chairman.

"Mr. Fish was a pioneer in establishing standards for the construction of safe boilers. He was associated with Col. E. D. Meier who, as president of the A.S.M.E. in 1911, was instrumental in appointing a committee of seven members to prepare boiler and pressure-vessel rules. As early as 1900 he worked with Col. Meier in an endeavor to set up standards in the American Boiler Manufacturers Association. There is no one who has a better knowledge of the safety movement for boilers than Mr. Fish who has followed it from the very start.

"The Committee was reorganized in 1914 and took up the work initiated by the group of seven. All was not easy going. The survival of the Committee was due to the loyalty of its members. It gained many friends but had its enemies, some of whom were in high standing in the Society. It owes its success to the devotion of its members and to those who co-operated in giving it sound advice.

"As the work progressed it became apparent that its importance and ramifications far exceeded the early expectations. It was aptly said that the committee had a bear by the tail and did not dare let go. All this bound the committee together more firmly than could have been done by any rule or precept.

"Mr. Fish was appointed a member of the Boiler Code Committee in 1918, and thus has served continuously for 26 years, the last three as chairman.

"He was endowed with the loyal spirit of the committee. He joined the others in freely contributing a vital part of his lifework. He will stand as a shining example to those who will continue the work.

"In view of all this, it is fitting to recognize and make a record of our feelings by taking action of the following:

Resolved: That the members of the Boiler Code Committee hereby express their grateful appreciation and thanks to Mr. Edwards Russel Fish for his valuable contributions to the work of the Committee in the formulation, revision, and interpretation of the various Sections of its Codes and also for his successful guidance of the Committee during his term as Chairman. We hope that in the future he will attend our meetings as often as convenient. We know he will continue to keep the best interests of the Committee and Society close to his heart and be ready to give helpful advice. The members sincerely extend their best wishes for health and happiness in the well-deserved leisure hours of his retirement."

H. W. Barlow Elected Dean at Texas A.& M.

HOWARD W. BARLOW has been elected dean of the School of Engineering by the board of directors of the Agricultural and Mechanical College of Texas.

Dean Barlow was graduated from Purdue University with the degree of B.S., M.E., in 1927, and holds the degrees of M.S. (Minnesota 1934), and Eng. Sc.D. (New York University 1941). At the time of election to dean of engineering, he had been serving as acting dean of engineering since June, 1944, and prior to that he was head of the department of aeronautical engineering. He joined the staff at the A.&M. College in 1940, coming from the aeronautical engineering department at the University of Minnesota.

Dean Barlow's background includes 12 years of teaching aeronautical engineering; consulting engineering practice; and the position as staff engineer for the Glenn L. Martin Co.

Edison Medal Awarded to E. F. W. Alexanderson

THE Edison Medal for 1944 has been awarded by the American Institute of Electrical Engineers to Ernst Fredrik Werner Alexanderson, consulting engineer, General Electric Company, "For his outstanding inventions and developments in the radio, transportation, marine, and power fields."

The Edison Medal was founded by associates and friends of Thomas A. Edison and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee composed of 24 members of the American Institute of Electrical Engineers.

E.I.C. to Meet at Winnipeg Feb. 7-8

THE Annual Meeting of The Engineering Institute of Canada will be held at the Royal Alexandra Hotel, Winnipeg, Manitoba, Canada, Feb. 7 and 8, 1945.

One of the features of the meeting is to be a symposium of papers on airline operations:

"Principles Involved in Operation of a Modern Airline," by J. T. Bain, superintendent of engineering and maintenance, Trans-Canada Airlines, Winnipeg.

"The Engineering Development of an Airline Aircraft," by J. T. Dyment, engineering superintendent, Trans-Canada Airlines.

"The Future of Radio Communications in Commercial Air Transportation," by S. S. Stevens, superintendent of communications and electronic development, Trans-Canada Airlines.

"New Developments in the Field of Materials and Processes," by P. E. Camoureux, materials and processes engineer, Trans-Canada Airlines.

Dunn and Jewett Honored

AT a dinner of the New York Electrical Society, Inc., held at the Engineering Societies Building, New York, N. Y., Jan. 10, 1945, Gano Dunn, Fellow A.S.M.E., and president, J. G. White Engineering Corporation, and Frank B. Jewett, chairman of the National Defense Research Committee, were made honorary members of that society. George F. Bateman, member A.S.M.E., and dean, School of Engineering of Cooper Union, who is president of the New York Electrical Society, conferred the honorary memberships "in recognition of their outstanding contributions to the advancement of science, engineering, and industry in this country and for their outstanding work in behalf of the New York Electrical Society itself."

1945 A.S.M.E. Committee Personnel List Sent on Request

MEMBERS of The American Society of Mechanical Engineers who wish to receive a copy of the 1945 issue of the Society Records containing committee personnel are requested to fill out and mail the accompanying form, or order by letter, addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York 18, N. Y.

This issue, to be published in February, will form a part of the Society Records Section of the Transactions as bound for library use.

A.S.M.E., 29 West 39th St.
New York 18, N. Y.

Please send me a copy of the February, 1945, issue of the Society Records.

NAME.....

ADDRESS.....

.....

ADAM K. STRICKER, JR., RECEIVES EXCEPTIONAL CIVILIAN SERVICE AWARD

(A member of The American Society of Mechanical Engineers was honored recently when Adam K. Stricker, Jr., industrial engineer with the Signal Corps, received the Exceptional Civilian Service Award, highest civilian commendation of the War Department, from Major General H. C. Ingles, Chief Signal Officer, at a ceremony in the Pentagon Building, Washington, D. C., December 11. Mr. Stricker, on war leave from the office of the chairman, General Motors Corporation, received a citation signed by the Secretary of War, reading: "In recognition of his outstanding planning and organizational ability in the development of systems which greatly facilitated the procurement, storage, packaging, and issue of Signal Corps equipment. By his perseverance and untiring efforts he contributed immeasurably to the nation's war effort.")

Orville Wright Honorary Member British I.M.E.

AT A luncheon held at the Engineers Club of Dayton, Ohio, on Friday, November 10, 1944, Orville Wright, honorary member A.S.M.E., was presented with a Certificate of Honorary Life Membership in The Institution of Mechanical Engineers (British).

The presentation was made by E. D. Smith, a member of the Dayton Section of the A.S.M.E. Attending the meeting were friends and other members of the Dayton Section, which, at the request of Robert M. Gates, president of the A.S.M.E. for 1944, made the presentation in behalf of the British organization.

An attractive booklet commemorating the occasion was issued to those present.

W. S. Newell Heads Naval Architects

ANNOUNCEMENT has been made of the election of William S. Newell, president, Bath Iron Works, Bath, Me., as president of The Society of Naval Architects and Marine Engineers for a term of two years beginning Jan. 1, 1945.

A.S.A. Officers for1945

THE re-election of Henry T. Bryans, executive vice-president and director of the Philadelphia Electric Company, was announced at the annual meeting, Dec. 8, 1944, of the Association at the Hotel Roosevelt, New York, N. Y. Mr. Bryans has already served one term as president and has been a member of the board of directors since 1941.

Other officers of the American Standards Association for the coming year will be:

Vice-President: George S. Case, chairman of the Board of the Lamson and Sessions Company (re-elected).

Chairman, Standards Council: H. S. Osborne, American Telephone and Telegraph Company (re-elected).

Vice-Chairman, Standards Council: E. C. Crittenden, National Bureau of Standards (re-elected).

A.S.L.E. to Hold Its Organization Meeting Feb. 8-9 in Chicago

LUBRICATION engineers representing industrial and transportation companies and educators have organized a nonprofit body known as the American Society of Lubrication Engineers with headquarters at 135 South LaSalle St., Chicago, Ill.

The society's first meeting will be held Feb. 8 and 9, 1945, at the Stevens Hotel, Chicago, Ill.

Officers of the new society are: G. E. Pritchard, Republic Steel Company, president; J. C. Peebles, dean of engineering, Illinois Institute of Technology, vice president; B. H. Jennings, professor of mechanical engineering, Northwestern University, secretary and treasurer.

National Oil and Gas Power Conference to Feature Diesel and Gas Engines

THE 18th National Oil and Gas Power Conference will be held at the Hotel Schroeder, Milwaukee, Wis., May 23–26, 1945. Under the direction of Bruno V. E. Nordberg, honorary chairman, and Robert Cramer, chairman of the Milwaukee Section, an exceptionally interesting program is being prepared.

Plant Visits

Milwaukee offers unusual opportunities for instructive inspection trips and the schedule for the meeting will be arranged so that engineers attending the meeting may visit plants manufacturing Diesel engines, Diesel and aircraft-engine superchargers, and welded engine frames.

Four or five technical sessions, under the direction of G. C. Boyer, chairman of meetings and papers committee, will feature papers on gas turbines and superchargers, industrial Diesel locomotives, engine bearings, tuning of exhaust-pipe systems, Diesel combustion, power-plant design, use of Diesels for stand-by and peak load, and engine testing.

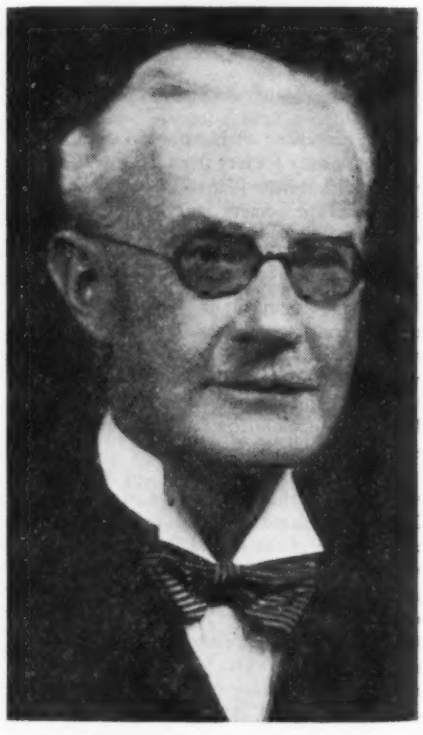
Exhibit of Diesel and Gas Engines

There will be an unusually large exhibit of Diesel and gas engines and accessory equipment, and it is expected that manufacturers will present new and improved units incorporating the developments of accelerated postwar research.

Eshbach to Head Washington Award Commission

ANNOUNCEMENT has been made of the election of Ovid W. Eshbach, dean of engineering, Northwestern Technological Institute, as chairman of the Washington Award Commission. The purpose of this commission is to select an engineer as recipient of the Washington Award, which is presented in recognition of devoted, unselfish, and pre-eminent service in advancing human progress. It is conferred each year at a joint meeting of members of the five participating societies, The Western Society of Engineers, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers.

The A.S.M.E. representatives on the Washington Award Commission are William S. Monroe and H. S. Philbrick.



SIR (STANDEN) LEONARD PEARCE

(Owing to delays in the mails, the photograph of Sir Leonard Pearce was not received in time for publication in the January issue. Sir Leonard Pearce was elected Honorary Member of The American Society of Mechanical Engineers in 1944. Certificate of Honorary Membership was accepted on his behalf by Sir William Wiseman at the 1944 Annual Dinner of the Society.)

President's Page

A Pension Plan for the Staff

A FAMILY AFFAIR

YOUR Society is nearly sixty-five years old. It has been growing in numbers, in importance, and in influence during that time and now is known nationally and internationally as the greatest organization in its field. Its success, of course, is due to the immeasurable efforts of its members, but in no small measure it is also due to the work of the employees of the Society, the staff, who have conscientiously and continuously performed their respective duties in carrying on the routine work of running the Society. When the members of this quiet and efficient group reach the age where they should no longer be required to continue in active service, we owe it to them to provide plans and means for their retirement. This is an obligation generally recognized by industry to those who have served long and faithfully. Two of our sister engineering societies already have pension plans in effect.

Your Council has had this matter under consideration for a number of years and has gradually built up a reserve fund for this purpose, but it is only recently that it was felt that the Society's income justified the adoption of a formal pension plan. Your Council has unanimously approved the proposed pension plan—a plan which, although not bountiful, is reasonable, and one which will give the faithful, long-service members of our staff a sense of security. The salaries paid the members of our staff have always been moderate and we feel that we owe them this consideration.

A special committee of Council will shortly send you a ballot for your vote on the adoption of a pension plan which we consider most necessary, merited, and fair. We earnestly recommend your approval.

Let us show that engineers are interested and able in humanitarian as well as technical matters. At home, particularly, we should practice what we preach. This is a family affair.

(*Signed*) ALEX D. BAILEY, *President*, A.S.M.E.

Among the Local Sections

Instruments and Regulators Division of Chicago Section Holds First Meeting

The Chicago Section held a meeting on Nov. 20, 1944, at the Central Y.M.C.A. Building. William H. Murphy, vice-president and secretary, Castings Patent Corporation, Chicago, Ill., spoke on "Nonferrous Castings by the Plaster-Mold Process." Mr. Murphy was exceptionally well qualified to tell about the interesting details of the process and what it means to the engineer.

At the December meeting in the Central Y.M.C.A. auditorium Dr. Ovid Wallace Eshbach, dean, Technological Institute, Northwestern University, gave a talk on "The Opportunities and Responsibilities of the Young Engineer in the Postwar Period," which was very well received.

A dinner meeting was held December 18 at the Chicago Engineers Club. This was the first meeting of the new "Industrial Instruments and Regulators Division," Chicago Section, and the subject discussed was "Industry's Postwar Requirements for Industrial Instruments and Regulators." Dr. Donald J. Bergmann, chief engineer, Universal Oil Products Co.; Donald G. Reid, mechanical engineer, Sargent and Lundy; L. R. Grandy, assistant superintendent of tests, Buick Motor Division, and Chester W. Bruce, combustion engineer, Republic Steel Co. Chicago plant, were the speakers, and each explained a separate phase of the subject. There were 92 in attendance.

Boston Section Discusses Unwritten Laws of Engineering

W. J. King was the speaker at the dinner meeting of the Boston Section on December 14, 1944, at the Engineers Club, Boston, Mass. He discussed some of the points of his articles on "The Unwritten Laws of Engineering," published in recent issues of MECHANICAL ENGINEERING (May, June, and July, 1944) and read letters from engineers which he had received, in favor of or against the various ideas set forth in the articles on engineering behavior. A very lively and worth-while discussion followed the address. Sixty members attended the dinner and the total attendance for the talk was 135.

Bridgeport Section Hears Lecture on Glass

At a dinner meeting on December 13, at Hotel Barnum, Bridgeport, Conn., the Bridgeport Section heard Charles John Phillips, manager, electronic sales department, Corning Glass Works, Corning, N. Y., talk on "Recent Developments in Glass." In his talk Mr. Phillips told of the present-day usefulness of glass to the scientist and layman, some of the problems in its manufacture and application to unusual situations, and the interesting properties of this widely used material. Mr. Phillips has been engaged in the research and manufacture of glass specialties for many years and is a recognized authority in this field. He has lectured before the Royal Canadian Institute, American Chemical Society, and many other societies and conferences.

Central Illinois Section Holds Two December Meetings

At the December 6 meeting of the Program Advisory and Executive committees, held at the Pere Marquette Hotel, Peoria, Ill., the members gave reports on various activities of the Section. W. W. Babcock told of the proceedings of the Group Delegates Conference held in New York, N. Y., Nov. 25, 1944; W. L. H. Doyle told of some of the results of meetings of committees of which he is a member, also held in New York, N. Y., during the Annual Meeting.

F. G. Ely was the speaker at the December 14 meeting at the Jefferson Hotel, Peoria, Ill. He described the mobile steam-power units which have been developed and installed in the temporary re-establishment of electric plants in war-distressed areas, illustrating his talk with slides, and explained the difference between floating and land units.

Detroit Section Hears Talk on the Round Engine

The Detroit Section held a meeting on Dec. 5, 1944, preceded by a dinner at the E.S.D. Auditorium, Detroit, Mich. The speaker was Allison C. Bayles, vice-president, American Engine Co. His subject was "An Examination of the Round Engine," and in the course of his speech Mr. Bayles covered the patent history of the Round engine and details of a recently built engine, in comparison with a conventional engine. Following him, E. S. Hall, manager of round-engine patents, described the method developed to pool all patents on this engine which is of benefit to the inventor and to the development of this type of engine. An interesting discussion followed. Two-hundred members and guests were present.

East Tennessee Section Hears Dean W. R. Woolrich

Dean W. R. Woolrich, director, Bureau of Engineering Research, University of Texas, spoke on the subject of prospective changes in education for mechanical engineers and trades at the East Tennessee Section meeting held at Kingsport, Tenn., on Dec. 1, 1944. There were 20 members and 50 visitors present.

Strain Gages Discussed at Fort Wayne Section

A dinner meeting of the Fort Wayne Section was held on Dec. 15, 1944, at the Chamber of Commerce, Fort Wayne. Mr. Tatnall, manager of the testing-machine research and development division, Baldwin-Southwark Division, Baldwin Locomotive Works, Philadelphia, Pa., spoke on "Strain Measurements and Strain Gages." He described and illustrated a strain gage and its application to the part to be tested, explained the operation of the gage, and included an interesting "ten-minute course in electronics." He also described the applications of the strain gage with reference to design of aeronautical structures and engines. A lively discussion period followed the lecture. It was considered by all present the best meeting of the year.

W. F. Guyton Speaker at Louisville Section

At the December 12 meeting of the Louisville Section at Cortlandt Hotel Grill, Louisville, Ky., members heard W. F. Guyton of the U. S. Geological Survey speak on the "Ground Water Resources of Louisville." In his talk Mr. Guyton called attention to the heavy requirements during the last several years and pointed out that they have exceeded the natural rate of replenishment of water contained in the gravel bed underlying that area, causing a serious shortage. Some reduction in pumping, he said, had been effected but more is needed.

Mid-Continent Section Hears Nathan Janco

One of the largest meetings of the year was held by the Mid-Continent Section at the Sherman Machine & Iron Works, Oklahoma City, Okla., on December 19. A buffet-style dinner was served by the company and an address of welcome was given by W. S. Sherman, vice-chairman.

The speaker of the evening was Nathan Janco, consulting engineer of Tulsa, Okla. Mr. Janco's subject was "Centrifugal Casting." Slides were shown to illustrate his talk, and to explain the fundamental principles of casting metals by the centrifugal process and the wide variety of shapes and sizes which have been formed by this method. Mr. Janco pointed out the superior quality possible and the economy of fabrication and said that a more extensive application of the process was anticipated. A lively discussion period concluded the lecture.

Philadelphia Section Hears Talks by Hill, Jordan, and Liversidge

"Gasoline From Catalytic Cracking" was the subject of the talk given by Dr. J. Bennett Hill of the Sun Oil Company at the meeting of the Philadelphia Section held at the Engineers Club in Philadelphia, Pa., on Nov. 28, 1944. Dr. Hill described the Houdry process of catalytic cracking, the equipment used and the cycle, and explained the uses and the future requirements for high-octane gasoline and the possibility of very high yields per

TRENTON MEMBERS OF A.S.M.E. AT LUNCHEON, HOTEL HILDEBRECHT, TRENTON, N. J., DECEMBER 13, 1944
(A. M. G. Moody presiding, with brief addresses by W. G. Christy, D. P. Eckman, A. M. Greene, Jr., C. R. Waller, and B. R. T. Collins.)

barrel of crude gasoline. After his talk there was a forty-minute question period from the floor.

Horace P. Liversidge, president, Philadelphia Electric and Gas Co., spoke on "How Public Utilities Have Met Increased Requirements in Wartime" at the December 12 meeting, at 7:30 at the Engineers Club, Philadelphia, Pa. In his talk Mr. Liversidge covered all angles of the electric utilities' participation in the war effort, with particular reference to the work done by individuals in the Philadelphia Electric Co. both for and apart from the company.

The second speaker, Henry Jordan, covered the subject of public water supply in wartime. There were present at the meeting 162 members and visitors.

Dean W. R. Woolrich Heard at Providence Section

At the November 28, 1944, meeting of the Providence Section at the Engineering Society Building, the Providence Section heard Dean W. R. Woolrich, of the University of Texas, discuss the development of food preservation from early days, the improvements brought about by inventions, and particularly the improvements in the refrigeration field. Eighty members heard the talk.

Dr. C. C. Furnas to Address Dinner Meeting of Junior Chemical and Metropolitan Groups, Feb. 21

DR. C. C. FURNAS of the Curtiss-Wright Corporation will be the guest speaker at the joint dinner meeting of the Junior Chemical Engineers of New York and the Junior Metropolitan Section Group of the A.S.M.E. on February 21, 1945. His talk will be of extreme interest and entertainment to everyone inasmuch as it will present Dr. Furnas' views concerning the future of aeronautics.

As everyone knows, the outlook for aviation is bright and sure but nevertheless, there are many wide-range problems yet to be solved. Of specific concern is the point of adapting airplanes to take their place along with the modern automobile. This and many more items present a challenge to the aeronautical industry which will be discussed by the speaker.

Speaker Exceptionally Well Qualified

Dr. Furnas is exceptionally well qualified and capable of tackling the problem of peering and probing into the future of aviation. He attained his Ph.D. at Michigan only four years after his bachelor's award at Purdue University. Since then, he has become well known as an author, writer, and scientist, being responsible for such works as "America's Tomorrow," "The Next 100 Years," "Man, Bread, and Destiny," "Storehouse of Civilization," and numerous articles on heat transfer, fluid flow, gas absorption, and distillation. Dr. Furnas has taken an active part in the American Chemical Society and today is the director of research for the airplane division of Curtiss-Wright in Buffalo.

Get-Together Precedes Dinner

The meeting is to be held on Wednesday, February 21, at Childs Restaurant, second floor, at 109 West 42nd Street. Dinner is scheduled for 6:30 p.m. and is to be preceded by an informal get-together at 6:00 p.m. to which all are invited. ($1.25). Those who cannot attend the dinner will be welcome at the meeting which will probably get under way about 7:30 p.m. The meeting will be in charge of Messrs. C. C. Davis, Elliott Company; P. B. Petty, Hydrocarbon Research; and M. R. Lyons of M. W. Kellogg Company.

Raleigh Section Entertains Dr. Stephen Timoshenko

On Nov. 23, 1944, the Raleigh Section and Student Branch of the A.S.M.E. entertained Dr. Stephen Timoshenko of Stanford University, Calif., at a luncheon at 12:30 p.m. in the State College cafeteria. Following the luncheon, Dr. Timoshenko was escorted on an inspection tour of the Diesel laboratory building and points of interest around the campus. At 3:30 he lectured at Withers Hall to more than three-hundred engineering students and members of the faculty on "Stress Analysis."

Later, members of the Section went to Durham, N. C., where the Duke University faculty honored Dr. Timoshenko at the Washington Duke Hotel. Then Dr. Timoshenko lectured on the Duke Campus where about 35 local-section members were present with student members in the hundreds.

Rock River Valley Section Hears W. T. Piper

At a dinner meeting of the Rock River Valley Section in the Rainbow Room, Faust Hotel, Rockford, Ill., on Dec. 11, W. T. Piper, president, Piper Aircraft Corporation, manufacturers of training planes for the past 15 years, spoke on "Private Flying." In his talk, Mr. Piper urged the building of airports even in small towns, to the extent of 10,000 or more, stressing the fact that if a community has poor train facilities, it is doubly important that they immediately plan to build a field. He said that by judicious planning for future expansion, the airfield will grow to meet the community's needs, and advised against building a huge million-dollar project.

There were 16 members and 67 guests in attendance.

Southern California Section Holds Joint Meeting

M. L. Arnold, Richfield Oil Corporation, was the speaker at the December 7 meeting of the Southern California Section which was held jointly with the California Natural Gaso-

line Association. Mr. Arnold's subject was "Compressor-Plant Vibration Problems." Prepared discussions of the subject were presented by representatives of six companies manufacturing machinery. Seventy-five per cent of the total attendance of 221 were A.S.M.E. members.

J. E. Bourland, Speaker at South Texas Meeting

The South Texas Section held a dinner meeting on December 7, in the Green Room of the Y.M.C.A. Building at Houston, Texas. The speaker of the evening was J. E. Bourland, North American Aviation Co., Dallas, Texas. His subject was "Management's Use of Work Simplification in Peacetime," and during his talk, Mr. Bourland emphasized the great importance of work simplification and what it had accomplished in the war effort and pointed out the part it must play in the postwar period. Showing of a film followed, demonstrating in pictures the results that have been accomplished. A number of slides used in the program at North American Aviation were also shown.

Reports Progress in Organizing Trenton Section

Arthur M. G. Moody, temporary chairman, Trenton Committee, called a luncheon meeting on December 13 at the Hotel Hildebrecht, Trenton, N. J., to discuss plans for an independent Section. Forty-two were in attendance. W. G. Christy, A.S.M.E. member from Jersey City, N. J., and D. P. Eckman of the Philadelphia Section attended and were most co-operative. Mr. Moody plans a program of at least three technical meetings this coming winter and spring.

"Steam Turbines Go to Sea" Talk at Utah Section

A meeting of the Utah Section, held jointly with the A.I.E.E. Section, was held at the Newhouse Hotel, Salt Lake City, on Nov. 3, 1944. The speaker was Donald R. Jenkins, steam-application engineer, Westinghouse Electric & Manufacturing Co., and an A.S.M.E. member of the Los Angeles, Cal., Section. He presented briefly the history and development of both land and marine turbine installations, with a description of the latest marine applications, including data on marine gearing. The talk was illustrated with lantern slides.

A.S.M.E. Local Sections

Coming Meetings

Baltimore. February 26. Engineer's Club of Baltimore at 8:00 p.m. Subject: "Opportunities for the Engineer in Postwar China," by K. Y. Chen, Chinese Legation, Washington, D. C.

Birmingham. February 15. Tutwiler Hotel, Birmingham, Ala., at 8:00 p.m. Subject: "High-Pressure-Boiler Design," by Otto de Lorenzi, director of education, Combustion Engineering Company, New York, N. Y.

Central Indiana. February 9. Antlers Hotel, Indianapolis, Ind., at 8:00 p.m. Subject: "Corrosion-Resistant Alloys," by John A. Gallaher, Chicago district manager, Haynes Stellite Corporation, Chicago, Ill.

Chicago. February 26. Flemish Room, Hamilton Hotel, 18 South Dearborn St., Chicago, Ill. Subjects: "Powdered Metals, Their Production and Use," by Dr. Joseph Drapeau, Jr., technical director, Metals Refining Company; "Machines for Compressing Powdered Metals," by James J. Kux, vice-president, Kux Machine Company; "Sintering Furnaces and Atmosphere," by Nordberg Koebel, director research, Lindberg Engineering Company.

Central Illinois. February 8. Hotel Jefferson, Peoria, Ill., dinner at 6:15 p.m. Program, 7:30 p.m. Subject: "The Supersonic Reflectoscope," by F. A. Firestone, professor of physics, research, University of Michigan.

Cleveland. February 8. Cleveland Engineering Society at 8:00 p.m. Subject: "The Engineer's Status in the Community," by Roy V. Wright, vice-president and secretary, Simmons-Boardman Publishing Company. Mr. Wright is a past-president of the A.S.M.E., and State Senator to New Jersey Legislature.

Colorado. February 1, 2, and 3. Shirley-Savoy Hotel, Denver, Colorado. The 29th Annual Convention of the Colorado Society of Engineers. The Convention will feature a most interesting program relating to "Future Planning." All engineers are invited to attend this Convention.

February 15. Albany Hotel, Denver, Col., at 6:30 p.m. Joint meeting with the Society of Automotive Engineers. Subject: "Preliminary Design of Helicopters," by K. D. Wood, professor of aeronautical engineering, University of Colorado, Denver, Colo.

Detroit. February 6. Auditorium of the E.S.D. Dinner at 6:30 p.m.; meeting at 8:00 p.m. Subject: "Precision Casting as Applied to Industrial Products," by Robert Kerr, Kerr Dental Manufacturing Company.

New Haven. February 14. Mason Laboratory at 8:00 p.m. Subject: "A Survey of Modern Fuels and Some of Their Engine Performance Characteristics," by W. S. Mount, chief automotive engineer, Socony-Vacuum Company.

Ontario. February 8. Meeting at Room C26, Mining Building, at 7:30 p.m. Subject: "Design and Materials for High-Pressure High-Temperature Valves, Fittings, Flanges, and Fabricated Piping," by E. R. Seabloom, supervising engineer, Crane Co., Research Laboratories, Chicago, Ill.

Plainfield. February 21. Elks Club, Elizabeth, N. J., at 8:15 p.m. Subject: "Jet Propulsion," by Alan Howard, General Electric Company, turbine-engineering division, Schenectady, N. Y.

Providence. February 6. Providence Engineering Society at 8:00 p.m. Subject: "Safety Color Code for Industry," by Messrs. George W. Badger of du Pont Paint Service Store, Providence, R. I.; Willard W. Thompson, Thompson Engineering Co., Boston, Mass.; and Herbert A. Johnson, Federal Products Corporation, Providence, R. I. This will be a symposium on the subject of improving production and safety in machine operations and will be illustrated with pictures showing conditions before and after adopting the safety color code.

Rock River Valley. February 19. Faust Hotel, Rockford, Ill. Meeting of the Rock River Valley Engineering Council, will be addressed by Mr. Van Deventer, president and editor of *Iron Age*.

Southern California. February 3. Kaiser Co., Iron & Steel Division, Fontana Steel Mill at 1:00 p.m. Luncheon will be served at Company cafeteria prior to inspection trip. This will be a field trip through the Fontana Steel Mill.

Washington, D. C. February 8. Potomac Electric Power Company Auditorium at 8:00 p.m. Subject: "Management's Educational Responsibility," by A. R. Stevenson, Jr., assistant to vice-president in charge of engineering, General Electric Co., Schenectady, N. Y.

West Virginia. February 27. Daniel Boone Hotel at 8:00 p.m. Subject: "Lubrication and Fuel Systems in Aircraft," by R. J. S. Pigott, chief engineer, Gulf Research & Development Company, Pittsburgh, Pa.

With the Student Branches

University of British Columbia Branch

Three meetings were held in November by the UNIVERSITY OF BRITISH COLUMBIA BRANCH. At the first, on Nov. 6, were presented two papers, "Supercharging Aero Engines," by Tom Scott, and "Maintenance of Electric Motors," by Frank Barry. At the second meeting, Nov. 20, Norman Latimor gave a paper on "Ship Templates" and Ed Cochrane discussed "Condensers." A film entitled "Logging in British Columbia" was shown at the November 27 meeting.

University of Cincinnati Branch

The University of CINCINNATI STUDENT BRANCH held three meetings in December, the first on December 6 which was a luncheon meeting in the Student Union Building, at which time the chairman asked the meetings, programs, and publicity committees to work in conjunction with the treasurer in turning out a budget for the year 1945, in the group's request for funds from the University's activities' appropriation.

At the December 13 luncheon, the meetings and programs committee outlined its plan for the future, which included formal meetings on specified dates, speakers and papers to be presented on the second and fourth Wednesdays of the month and dinner meetings, movies, inspection trips, athletic events, and a "co-op day" program to be planned with the A.S.M.E. taking a leading part in the procedures.

Colorado University Branch

At the November 6 meeting of the COLORADO UNIVERSITY BRANCH the members heard Mr. Van Valkenburgh, 3rd, who recently returned from India and Australia as an engineer on a Liberty ship, and who has had very close connections with the U. S. Patent office. His talk was on "Patent Laws and the Engineer" and in

the course of his speech he explained a number of technical points that often confuse patentees.

After a brief business meeting on November 8, the BRANCH elected new officers for the coming semester as follows: James Hurner, chairman; Gordon Campbell, vice-chairman; John Pickett, secretary; and George Buroker, treasurer. The session was concluded by a motion picture entitled, "Aircraft and Their Production," lent through the courtesy of the Bureau of Mines.

Columbia University Branch

The COLUMBIA BRANCH met on November 6 to elect new officers for the coming semester, and to prepare a schedule of programs for the term. The newly elected officers are: Leo J. Faneuf, president; Kenneth E. DeGennaro, vice-president; Donald J. Sengstaken, secretary; and William T. Murphy, treasurer.

For the purpose of encouraging new men to join, the COLUMBIA UNIVERSITY BRANCH held the second meeting of the new term on November 30, 1944. Four movies were shown: a technicolor production of the evolution of the flying fortress entitled "Fortress of the Sky;" "Daredevil Driving by Jimmy Lynch;" "How Steel Is Made;" and "Making a V-type Engine." The last two films were of great interest since they dealt with the subjects the members are studying. It was announced that John E. Englund has replaced Prof. Karl F. Kayan as honorary chairman of this Branch. A third meeting was planned, to include both a speaker and movies.

Duke University Branch

At the November 14 meeting of DUKE BRANCH, members discussed plans for a tour of the shipyards in Wilmington, N. C., and selected A. J. Steele and F. A. Shoemaker to make the necessary arrangements. An invitation also was accepted from the A.I.E.E. to attend one of the latter's meetings in the near future.

The BRANCH held its December 12 meeting at the Asbury Building at 7 p. m. Officers and committees made reports and various plans were discussed for the future, among them a possible inspection trip to Wilmington, N. C., when the U.S.O. in Wilmington could provide lodging for the Navy Students on January 13.

Georgia School of Technology Branch

Officers elected at the November 7 meeting of GEORGIA SCHOOL OF TECHNOLOGY BRANCH are as follows: J. E. Bolt, chairman; H. C. Buttery, vice-chairman; and W. C. Rich, secretary-treasurer. After the election of officers, plans were prepared for a program of field trips to be made during the present term.

University of Idaho Branch

On Oct. 31 the UNIVERSITY OF IDAHO BRANCH elected officers to replace those who did not return for study in the fall of 1944. Elected were: Joe Doss, chairman; Fred Watson, vice-chairman; Bill Abbott, secretary and treasurer; Ray Dills, representative.

At the Nov. 21 meeting at Kirtley Engineering Laboratory plans were discussed for 1945, new members introduced, and a short talk given by chairman H. F. Gauss on the gas turbine. The rest of the evening was spent by the members in inspection of Diesel and gas engines.

Illinois Institute of Technology Branch

A regular meeting of the ILLINOIS INSTITUTE OF TECHNOLOGY BRANCH was held at the Institute on Oct. 28. The following new officers were elected: Roy Norrlander, president; Robert Thurston, vice-president; John Erickson, secretary; Angelo Caliendo, treasurer. After the business meeting a film entitled "The Fourth Kingdom" was shown; this film illustrated the many applications of plastic materials.

The opening rally of the second term 1944-1945 was held on November 22, when program, membership, and publicity committee members were announced. Dr. R. A. Budenholzer, honorary chairman, told of a new course, "M.E. 409," which includes preparation of a paper to be submitted at the Northwestern Conference next March. At that conference prizes are awarded, and the Branch hopes to carry off several of these prizes. R. M. McGee was the guest speaker and he illustrated his talk on steel with original color films on research at the Jones & Laughlin Steel Co., dealing with testing procedures and devices. A discussion period followed.

Lafayette Branch

The December, 1944, meeting of LAFAYETTE BRANCH was devoted to the showing of the Kodachrome motion picture "Die Casting," provided through the courtesy of The New Jersey Zinc Company. This proved to be one of the finest pictures seen by the Branch and is recommended as a top attraction to all other branches. The faculty present were so impressed with the film that it was held over an extra day in order to exhibit it to a freshman engineering orientation class of 65 students. Chairman Rush delivered a speech of welcome to the audience and stressed the advantages of joining the A.S.M.E.

Maryland Branch

The first fall meeting of MARYLAND BRANCH was held on November 8, at which William Greene, of engineering research, discussed "Germany's Robot Bombs." Mr. Greene told the members that this weapon, though skillfully devised, was comparatively simple to construct. He then gave a description of the new V-2 weapon, after which a general discussion was held.

Michigan State College Branch

MICHIGAN STATE COLLEGE BRANCH held a short business meeting on Oct. 17, 1944, to discuss future activities, and to elect a vice-chairman to replace Jack Peyton who left to join the Merchant Marine. Terry Lobdell, senior, was elected. It was voted to continue the present officers until 1945. Committees were appointed for membership and for entertainment. An inspection trip through the Oldsmobile Forge plant in Lansing, Mich., was planned for November 17. Because of the small number of men in the Branch, it was decided to have the picture for the college yearbook taken with the civil and electrical engineers. The next meeting was planned for after the inspection trip.

Minnesota Branch

New officers elected at the November 17 meeting of MINNESOTA BRANCH, which is composed entirely of Navy V-12 students, are Robert L. Kulp, chairman; Leroy C. Horpedahl, vice-chairman; Donald C. Myntti, secretary, and William J. Mullenmeister, treasurer. The incoming group succeeds the officers who have left for attendance at midshipman school. Membership and program committees were also appointed, after which plans were prepared for an extensive membership drive to include both civil and naval students. An interesting film on "Hydraulic Transmissions" concluded the session.

Nebraska Branch

A brief business session was held on October 18 by NEBRASKA BRANCH, after which Professor Weiland explained the value and many opportunities open to students by membership in the A.S.M.E.

New Mexico A.&M. Branch

"Fortress of the Sky," a motion picture depicting production methods employed in constructing a B-17, featured the November 2 meeting of NEW MEXICO A.&M. BRANCH, held jointly with members of the A.I.E.E., a few members of the freshman engineering class, and several college people. This Branch met again on November 9, with the dean of engineering and various members of the freshman engineering class, to view a technicolor sound movie, "PT-19 Trainer," which described the construction of an improved trainee plane recently produced by Fairchild.

New Mexico State College Branch

Through the courtesy of the Allis-Chalmers Company, the New Mexico State College was the first college to view the film "Tornado in a Box" on December 18, at State College. Prof. M. A. Thomas, head of the electrical-engineering department obtained this film which portrays the history of the gas turbine and its principle of operation. Its reheat and regenerative cycle and efficiency were explained thermodynamically as well.

Following the showing of the film the BRANCH had a separate meeting when they elected the following officers for the new semester in 1945: Chester A. A. Rowland, Jr., president; Joe T. Budenholzer, vice-president; Eva Blanchard, treasurer and reporter; Pete F. Triviz, secretary.

New York University Branch

A representative of the Odel Precision Products Co. spoke at the Nov. 30 meeting of the New York University Branch at the Guggenheim Building at 8 p.m. on the subject of hydraulic mechanisms for power transmission and remote control, particularly as applied to bomber and fighter planes. He illustrated his talk with samples of the parts and units manufactured by the company, and explained each in as great detail as permitted by regulations. Two films were shown, explaining the principles of fluid statics and their application in hydraulic mechanism. Some interesting smoke films of air flow past foils and obstructions were also shown.

Northeastern University Branch

At the meeting on December 19, 1944, officers for the 1945 season were elected. They were Arthur L. Chase, president; Ralph G. Briggs, vice-president; Thomas L. McDonough, secretary; Robert J. Harrison, treasurer; Vincent Corapi, program chairman; Howard N. Kaufman, social committee chairman, and Thomas Chin, publicity director. A program of short talks by the members followed the election.

Ohio State University Branch

The last meeting of the fall quarter of OHIO

STATE UNIVERSITY BRANCH was held at the Robinson Laboratory on Dec. 16 when the following new officers were elected: William T. Clark, chairman; George S. Kepley, treasurer; Dorothy A. Jarvis, secretary. Plans were discussed for the next quarter, and suggestions taken.

University of Pennsylvania Branch

The December meeting of the UNIVERSITY OF PENNSYLVANIA BRANCH which was held at the engineering building, was made most interesting by a talk given by F. W. Miller, chairman of the Philadelphia Branch of the A.S.M.E. He spoke to the members on the advantages of remaining active in the A.S.M.E. after graduation and told of his experiences at Camp Thomas, R. I., with the Navy Sea Bees. Following his talk, a film "Unfinished Rainbows" dealing with the development of aluminum, was shown. It was decided that the local A.S.M.E. BRANCH would be host for a joint meeting of all the local engineering societies in January.

Polytechnic Institute of Brooklyn Branch

Modern methods of analyzing engine performance, and the types of locomotives preferable from an economic viewpoint were discussed by W. F. Collins, a representative of the New York Central Railroad System, at the meeting of the POLYTECHNIC INSTITUTE OF BROOKLYN, N. Y., BRANCH at the lecture room on November 21, 1944. Fifty-five members and guests attended the talk.

Purdue University Branch

On Tuesday afternoon, November 28, 4 p.m., the PURDUE UNIVERSITY BRANCH met to hear Prof. F. L. Serviss of the department of metallurgy, speak on "Strategic Materials." In his talk Professor Serviss listed some of the present-day strategic materials and pointed out the geographical problems confronting our industries in obtaining these materials. He then discussed the political problems involved in securing such materials during the last twenty-five years. Then followed an election of officers for 1945: John H. Colby, chairman; G. W. Barnes, O. E. Flint, C. P. Kolthoff, H. Phillips, vice-chairmen; W. K. Price, secretary-treasurer; Prof. R. W. Leutwiler, honorary chairman.

A joint meeting of this BRANCH and the A.I.E.E. was held on Thursday evening, November 30, in the electrical-engineering building. The program included a lecture and demonstration of a new electronic recording potentiometer developed by the Brown Instrument Company. W. P. Meyers, district field engineer for the Brown Instrument Company, explained the operating principles of this new instrument. In his discussion, Mr. Meyers presented the complete circuit diagram of the instrument.

Rice Institute Branch

At a brief business meeting of the RICE INSTITUTE BRANCH on Dec. 7, at the chemistry lecture hall, officers for the coming term were elected: J. B. T. Downs, honorary chairman; A. J. Chapman, chairman; G. E. Allison, secretary; R. E. Rhoades, treasuer. Twenty-two new men applied for membership. Announcements were made of programs for January and February.

University of Toronto Branch

On Monday, Dec. 11, a combined dinner meeting of the Mechanical Club and UNIVERSITY OF TORONTO BRANCH was held at Diana Sweets restaurant, Toronto, Ont., Canada. The speaker was John Hall, assistant to the vice-president of the Combustion Engineering Corporation. Mr. Hall was graduated from McGill University in 1921 and has since been active in heat-power engineering. He opened his discussion with a brief history of steam generation and gave definitions of terms used in this work. By means of slides he illustrated in detail some of the more outstanding boiler installations on this continent.

Tufts College Branch

The senior class of TUFTS COLLEGE BRANCH traveled to Northeastern University on December 14 to hear W. J. King speak on "The Unwritten Laws of Engineering." The talk was of vital interest to the group. Mr. King stressed those points of an engineer's behavior to be expected of any well-bred engineer.

At the December 20 meeting a film entitled "Carburetion" was shown.

The second of a series of Navy films on internal-combustion engines was shown at the December 29 meeting. Comments were made by Prof. D. A. Fisher.

University of Wisconsin Branch

Theo. Swansen of the supercharger department of Allis-Chalmers Company, gave a most interesting talk on turbosuperchargers at the Nov. 28 meeting of the UNIVERSITY OF WISCONSIN BRANCH held at Old Madison. He illustrated his talk with a cutaway model of the turbosupercharger. A discussion from the floor followed.

Worcester Polytechnic Institute Branch

WORCESTER POLYTECHNIC INSTITUTE BRANCH visited the J. Woodman Higgins collection of medieval arms and armament and pressed-steel products through the Worcester Pressed Steel Company, on December 7, 1944. Upon arrival at the museum, the members were met by a lecturer who explained, in chronological order, the characteristics of different types of armor suits, and related interesting stories concerning the museum pieces. A modern wing of the museum was also visited, containing recent exhibits in pressed-steel products. Later in the evening the members visited the shops where war production of "Pressteel" products was in progress. Among the machines in use was a fifty-ton press.

Yale University Branch

The YALE UNIVERSITY BRANCH held two meetings in November, 1944, the first on November 21, at Mason Laboratory, when Macauley Whiting was elected to represent the Branch at the Old Guard Dinner held during the Annual Meeting of the A.S.M.E. in New York. Several of the members then gave short talks on various subjects. The November 28 meeting was held at the same place, when again talks by five members were enjoyed.

A.S.M.E. Calendar

of Coming Meetings

April 16–18, 1945
A.S.M.E. Spring Meeting
Hotel Statler
Boston, Mass.

May 18–19, 1945
A.S.M.E. Applied Mechanics Division Meeting
Hotel Statler
Buffalo, N. Y.

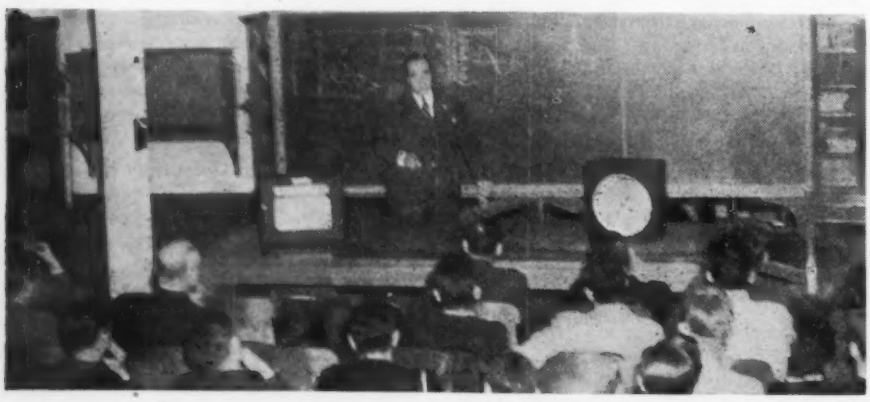
May 23–26, 1945
A.S.M.E. Oil and Gas Power Division Meeting
Schroeder Hotel
Milwaukee, Wis.

June 11–14, 1945
A.S.M.E. Aviation Division Meeting
University of California
Los Angeles, Calif.

June 17–21, 1945
A.S.M.E. Semi-Annual Meeting
Stevens Hotel
Chicago, Ill.

October 1–3, 1945
A.S.M.E. Fall Meeting
Netherland Plaza Hotel
Cincinnati, Ohio

November 26–30, 1945
A.S.M.E. Annual Meeting
Hotel Pennsylvania
New York, N. Y.



W. P. MEYERS OF THE BROWN INSTRUMENT COMPANY SPEAKING BEFORE A MEETING OF THE PURDUE STUDENT BRANCH

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

AUTOMATIC-CONTROL ENGINEER, age 36, with 9 years' experience, desires connection with progressive company to organize and execute development program on pneumatic control instruments based on advanced principles. Me-883.

PLANT MANAGER-SUPERINTENDENT. Seasoned executive with mechanical background and *punch* to get out production. Metal stampings, screw-machine products, castings, forgings, dies, tools, jigs, fixtures. Electronic devices. Medium-light assembly. Me-884.

MECHANICAL ENGINEER, 42, M.E. degree and extensive postgraduate training; varied experience in charge of research, development and design of electrical, mechanical, and aircraft equipment, seeks new connection with attractive opportunity. Me-885.

ENGINEERING GRADUATE, one year machine shop, four years' shipyard experience in research, testing, and design. Broad technical and business training. Desires plant development, or sales engineering. Me-886.

POSITIONS AVAILABLE

ENGINEERS with at least 10 years' experience in design and development of heavy machinery or similar experience, for research and development work both as to design and from industry study points of view. Permanent, excellent opportunity. Write complete details of experience and personal record. $4000–$6000 year. Pennsylvania. W-4637.

MECHANICAL ENGINEER with design and layout experience on pressure vessels and gas equipment. Must have had some plant-maintenance experience. Temporary. $5000–$6000 year. Ohio. W-4734.

CHIEF ENGINEER, 40–45, to take charge of engineering department of large, essential, nationally known manufacturing concern, operating large number of plants throughout the United States and in many foreign countries. Experience in process engineering, construction engineering, and general supervision of plant engineering work in industrial, chemical or food-processing fields necessary. Will act as assistant to chief engineer, who plans to retire when his successor has demonstrated to him that he is well grounded technically to assume direction of the engineering department, and has the ability to enlist zeal of engineering staff and co-operation of factory managers. Must have professional-engineering license. $15,000 a year. New York, N. Y. W-4748.

DIRECTOR OF TRAINING for metal plant of 1000 employees. Must have complete knowledge of job-instruction training, particularly as given by War Manpower Commission. $5200–$6000. New York, N. Y. W-4771.

MECHANICAL ENGINEER, under 50, with construction experience to do drafting and layout in connection with design of sewage treatment and water purification equipment and plants. $5000 year. New Jersey. W-4799.

ASSISTANT CHIEF ENGINEER, 35–45, perferably with experience in food product plants or with general plant-engineering knowledge involving all fields of engineering. Must be good administrator and executive. $7500–$8500 year. New Jersey. W-4804(*a*).

ENGINEERS. (*a*) Chief product engineer for planning and general supervision of plant layout, equipment specifications, tool and gage design, installations, and expediting for setting up of a heavy-shell-production line. $7200 year. (*b*) Production engineer to act as assistant project engineer to supervise plant layout, and fixture, tool and gage design groups working on heavy-shell production. $6000 year. (*c*) Designer capable of layout and supervision of detailing machine-tool chucks, fixtures, cutting tools, and gages for production of heavy shells. $4800 year. (*d*) Plant layout and equipment engineer capable of layout for conversion of heavy-shell line for redesigned ammunition involving selection and adaptation of equipment and rearrangement of facilities and services. $3600 year. Pennsylvania. W-4820.

ENGINEERS. (*a*) Industrial engineer, young, with general mechanical and some electrical training. Work involves design, plant layout, product testing, and development work. (*b*) Development and research engineer, young, either mechanical or with good background in physics. Some experience in glass preferred. Considerable laboratory work involved. $4000–$4500 year. Connecticut. W-4826.

VETERANS' COUNSELOR with personnel experience and technical knowledge, for work with large company. Will assist in re-establishing returning veterans. Would have to clear with veteran agencies, labor unions, and other agencies interested in veterans. Must be veteran of World War II. $4000. Connecticut. W-4833.

DIRECTOR OF ENGINEERING, about 50, mechanical graduate with both mechanical and electrical experience, to direct engineering division of recognized national organization. Should have considerable experience on special machinery and knowledge of basic metallurgy of high-frequency heating application, arc welding, resistance welding, and other methods of joining metals. Ohio. W-4842D.

INDUSTRIAL ENGINEER, 35–50, graduate engineers preferred. Must be thoroughly experienced and qualified to act in consulting capacity in such industrial phases as wage administration, incentives, job evaluation, production control, etc. Prefer men who have had broad experience in private industry. $5200–$7800 a year plus expenses. Connecticut. W-4851.

DEVELOPMENT ENGINEERS, mechanical, thoroughly experienced in design and development of hydraulic controls with servomechanisms. Sound foundation in applied mathematics and physics preferred. $5000–$7000 year. New York, N. Y. W-4854.

MECHANICAL ENGINEER, 25–30, with general interest in plant operations essential. Work involves analysis of processing equipment, supervisory work relative to plant equipment in proposed new mill processing plant. Training or experience on refrigeration equipment, conveyer operation, and bottling procedures desirable. Good opportunity. $3000–$4000 year. Pennsylvania. W-4866(*a*).

INSTRUCTOR to head up training work and do some teaching for industrial plant. Will train draftsmen, and start classes for experienced draftsmen and young engineers to prepare them for better positions. N. Y. State. W-4875.

ASSISTANT INDUSTRIAL-RELATIONS MANAGER, 35–40, with considerable mill or manufacturing experience to handle union matters, personnel problems of insurance, housing, transportation, etc. and prepare various reports for management and government agencies. $4200–$4800 year. Pennsylvania. W-4884.

PLANT MANAGER for plant having complete iron and brass foundry and machine shop, and employing 600 to 700 persons. Company now

[1] All men listed hold some form of A.S.M.E. membership.

Index to 1944 Volume of Mechanical Engineering

AS Section 2 of the January, 1945, issue of the Transactions of the A.S.M.E., separate indexes to the Transactions and to MECHANICAL ENGINEERING for 1944 were mailed to the A.S.M.E. membership.

An additional copy of the index to MECHANICAL ENGINEERING may be secured from A.S.M.E. Headquarters, 29 West 39th Street, New York 18, N. Y., by sending ten cents for handling charges.

doing war work but position has good post-war possibilities. $8000–$10,000 year plus bonus. Eastern Pennsylvania. W-4887.

ENGINEERS. (*a*) General foreman with considerable experience on light machine work for supervision of machining and assembly of motion-picture equipment. Salary, $5000–$6000 year. (*b*) Industrial-relations manager with personnel experience especially along labor-relations lines in small metal-manufacturing plant. $4000–$5000 year. New York, N. Y. W-4891.

JUNIOR MECHANICAL ENGINEER to assist plant engineer in supervising installation of equipment, design of materials-handling equipment, plant layouts, scheduling, maintenance, inspection, and development of labor-saving devices. Permanent position in plastics field. $3000-$4000 year. New York State. W-4902.

POWER PLANT OPERATING ENGINEER. Experience must qualify him to take full charge of 1500-kw turbine generator plant. Give age, detailed experience record, education, and salary desired, in first letter. References will not be contacted until after interview. Salary open. Michigan. D-2100.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after February 26, 1945, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ADAMS, JAMES F., JR. (LIEUT.), Rochester, N. Y.
ADDOMS, JOHN F., Alhambra, Calif.
AMADON, FRANK W., Radburn, N. J.
ANDERSON, J. HILBERT, Phillipsburg, N. J.
BACHE, WILLIAM H., Aberdeen Proving Ground, Md. (Re)
BALLINGER, PHILIP F., Savannah, Ga.
BAME, MORRIS, Toledo, Ohio
BANCROFT, GILBERT H., Horseshoe Bay P. O., B. C., Canada
BANGE, GEORGE E., Wichita, Kansas (Rt & T)
BARBER, THOMAS C., Chicago, Ill.
BASON, GEORGE O., Philadelphia, Pa.
BAVETTA, VINCENT E., Brooklyn, N. Y.
BLOCH, LEONARD L., New York, N. Y.
BOUSHELL, C. C., E. Stroudsburg, Pa.
BRYAN, W. L., JR. (LIEUT.), Long Island City, N. Y. (Re)
BUTCHER, ROBERT O., Swamscott, Mass.
CHANDLER, EDWARD F., Brooklyn, N. Y. (Rt)
DEBNEY, GEORGE C., Beaumont, Texas
DUNN, ROYAL C. (LIEUT.), Minneapolis, Minn.
ELLIOTT, G. D., Wolverhampton, England
FAHRLANDER, H. W., SR., Hamilton, Ohio
FENTON, CLIFFORD M., Trenton, N. J.
FRADENBURGH, JOHN, Worcester, Mass. (Rt & T)
FRANCIS, JOSEPH S., Chicago, Ill.
GAINES, WM. PENDLETON (LIEUT.), Birmingham, Ala.
GISMOND, HOWARD E., Dayton, Ohio
GODFREY, WALTER, Queens Village, N. Y.
GREEN, CHARLES H., New Orleans, La.
GREENBERG, YALE J., Brighton, Mass. (Rt & T)
HALLORAN, JOSEPH M., West Haven, Conn. (Re)
HARPER, W. C., JR., Philadelphia, Pa.
HAYES, THOMAS J. (MAJ. GEN.), Falls Church, Va.
HECKER, ROLAND FRED, Cincinnati, Ohio
HOFFMAN, IRWIN R., Great Neck, N. Y. (Rt & T)
HOLLISTER, EZRA, Los Angeles, Calif.
HOWARD, EDWARD A., Altadena, Calif.
HURLEY, GEORGE H. (MAJOR), Washington, D. C. (Rt & T)
JENSEN, IRVING, Walnut Creek, Calif.
JONES, LESLIE W., Elmira, N. Y.
JONES, ROBERT M., JR., Oak Ridge, Tenn. (Re)
KAISER, E. A., Cincinnati, Ohio (Rt)
KATZ, DONALD L., Ann Arbor, Mich.
KRAFVE, RICHARD E. (MAJOR), Baltimore, Md.
LAWSON, S. C. D., Yellow Springs, Ohio
LIND, JOHN E., Louisville, Ky.
LINDEROTH, L. SIGFRED, JR., Wenham, Mass.
LONDON, W. P., Niagara Falls, Ontario
LYON, JAMES A., Crestwood, N. Y.
LYONS, FRANCIS T., Syracuse, N. Y.
MACNAB, A. C., Hespeler, Ontario
MATHIS, EUGENE, Chicago, Ill.
MATTER, A. J., Park Ridge, Ill. (Rt)
MEYER, ROBERT M., Arlington, Va.
MILLER, LAURENCE G., Oak Park, Ill.
MORRO, JOHN J., Upper Darby, Pa.
NEAL, R. A., Pittsburgh, Pa.
NICHOLS, R. L., Beaumont, Texas
NOY, JACK M., Langeloth, Pa.
OFFNER, WALTER W., Seattle, Wash.
OLSON, MALVEN L., Indianapolis, Ind. (Rt & T)
ORNING, A. A., Pittsburgh, Pa.
PARKER, ROBERT B., Edgewood, R. I.
PATTERSON, MOREHEAD, New York, N. Y.
PERRY, RUSSELL S., Charleston, W. Va.
PLUMMER, G. A., Wolverhampton, England
POLSTON, JOHN RAY, Tulsa, Okla.
RUSK, GLENN ORDE, Orinda, Calif.
SCHMIDT, WARREN, Bridgeport, Conn.
SCHUMAN, F. J., Charleston, W. Va.
SHELLOGG, RICHARD F., Brooklyn, N. Y.
SMITH, FRANK J., Philadelphia, Pa.
SMITH, ROGER R., Gardner, Mass.
STANDERWICK, REGINALD G., Marblehead, Mass.
STANITZ, JOHN D., Lakewood, Ohio
STAPLETON, PATRICK G., New York, N. Y.
TAYLOR, EDWARD S., Lincoln, Mass.
TERRE, B. R., Kenmore, N. Y.
UNDERWOOD, ARTHUR F., Detroit, Mich.
WALKER, JAMES J., Charleston, W. Va.
WATKINS, AROLD, Rochester, N. Y. (Rt & T)
WEIR, FREDERICK U., San Francisco, Calif.
WHITMORE, RALPH D., Cambridge, Mass. (Rt)
ZEITLER, E. C., San Diego, Calif.
ZISMAN, WILLIAM A., Washington, D. C.

CHANGE OF GRADING

Transfer to Fellow

STEWART, C. D., Pittsburgh, Pa.

Transfers to Member

ALMAN, LAWRENCE C., Rochester, N. Y.
DAVIS, JESS H., Louisville, Ky.
HYLER, LOIELL L., Cedar Rapids, Iowa
MACNEALE, NEIL, Cincinnati, Ohio
MOODY, ARTHUR M. G., Trenton, N. J.
PLETTA, WILLIAM H., Chicago, Ill.
RICONDA, LEO J., City Island, N. Y.
SAGINOR, S. V., Kent, Ohio
THOMPSON, J. GEO. H., College Station, Texas

Transfers from Student-Member to Junior 25

Necrology

THE deaths of the following members have recently been reported to headquarters:

CHAPMAN, WALTER W., December 5, 1944
CONTERMAN, FRED A., December 6, 1944
DORBANDT, FRED C., September 12, 1944
HERNON, JOSEPH L., December 15, 1944
HUBLEY, GEORGE W., April 8, 1944
HUTCHISON, MILLER R., February 16, 1944
JOHNSON, PHILIP G., September 15, 1944
KIRBY, THEODORE M., November 26, 1944
KNIGHT, WILLIAM, December 26, 1944
OSBORNE, LOYALL A., August 18, 1944
SCHIEREN, GEORGE A., December 7, 1944
SCOTT, CHARLES F., December 17, 1944
SPIRO, WALTER J., December 30, 1944
TUNNADINE, JOHN, August, 1943

A.S.M.E. Transactions for January, 1945

THE January, 1945, issue of the Transactions of the A.S.M.E. contains two sections:

Section One:

Methods of Joining Aluminum-Alloy Products, by E. C. Hartmann, G. O. Hoglund, and M. A. Miller

Effect of Some Environmental Conditions on the Mechanical Properties of Cellulose Acetate and Cellulose Nitrate Plastic Sheets, by T. S. Lawton, Jr., T. S. Carswell, and H. K. Nason

Variable Heat-Transfer Rate Correction in Multipass Exchangers, Shell-Side Film Controlling, by K. A. Gardner

Experimental Confirmation of Predicted Water-Freezing Rates, by R. A. Seban and A. L. London

Investigation of Friction and Wear Under Quasi-Hydrodynamic Conditions, by R. G. Larsen and G. L. Perry

The Friction Properties of Various Lubricants at High Pressures, by John Boyd and B. P. Robertson

New Method of Calculating Natural Modes of Coupled Bending-Torsion Vibration of Beams, by N. O. Myklestad

Section Two:

Society Records including indexes to publications

• Keep Informed . . .

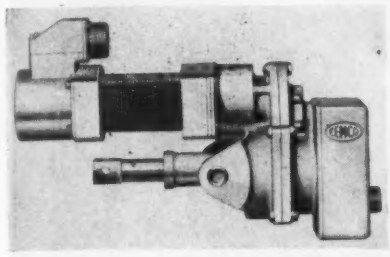
Announcements in this section are supplied by current advertisers in MECHANICAL ENGINEERING and A.S.M.E. MECHANICAL CATALOG. This section is restricted to these advertisers.

- *NEW EQUIPMENT*
- *BUSINESS CHANGES*
- *LATEST CATALOGS*

Available literature may be secured by addressing a request to the Advertising Department of MECHANICAL ENGINEERING or by writing direct to the manufacturer and mentioning MECHANICAL ENGINEERING as a source.

• NEW EQUIPMENT

Electric Motor Driven Linear Actuating Unit

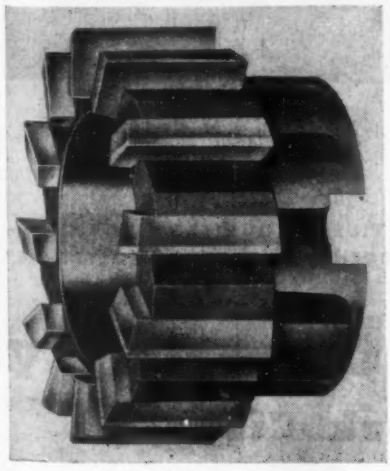


An electric motor driven linear actuating unit, designed for unusual installation and operational conditions, is announced by Electrical Engineering & Mfg. Corp., 4606 West Jefferson Blvd., Los Angeles, Calif.

Engineered specifically to extend "dive brakes" on Lockheed P-38 Fighters, the actuating units must guarantee uniform operation in the space of seconds, meet precise weight and size specifications and, in addition, fit the wing panels of present P-38's as well as earlier models now in combat zones.

The principal technical features of this 10,000 rpm, 1¼ hp self-contained actuating device include a double integral gear reduction unit to operate the screw jack actuator, magnetic clutch and brake, a control gear reduction drive to turn cams for opening and closing specially developed limit travel switches. Maximum load is 3,000 pounds, with 2½" travel on the jack in less than 2 seconds. An additional take-off shaft is provided for positioning indicator.

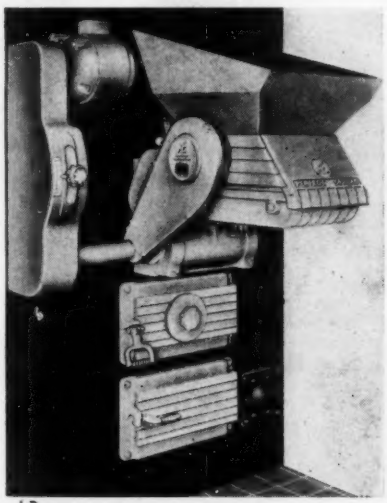
Shell End Mills with Haynes Stellite Blades



Small standard shell end mills with brazed-in blades made of Haynes Stellite cobalt-chromium-tungsten alloy are available from Haynes Stellite Co., Unit of Union Carbide & Carbon Corp. These cutters are furnished with blades of either Haynes Stellite 98M2 or Star J-Metal brazed into a steel body. Diameters range from 1¼ to 6 inches, with face thicknesses from 1 to 2¼ inches. These cutters are supplied ready for use. They are used for milling aluminum, bronze, cast iron, brass, alloys, and some steels. These shell end mills with brazed-in blades can be obtained from Haynes Stellite Co., Kokomo, Indiana.

New AE Perfect Spread Stoker Saves Fuel

A new spreader-type stoker based on one of the latest improved methods of low cost steam production, and backed by 38 years of stoker engineering experience, has been announced by American Engineering Co. "Streamlined with a purpose," this modern, completely automatic stoker efficiently burns all kinds and grades of solid fuels, including by-products and plant refuse, whether wet or dry. This versatility permits the utilization of favorable market prices and fuels available in any locality.



Extremely clean and quiet in operation, the AE Perfect Spread Stoker gets up steam on instant demand with its combination of an all-speed, non-clog feed, uniform fuel spread by the reliable overthrow method, and thorough combustion through forced draft and exclusive grate design. The stoker can be easily installed under most existing boilers to produce steam from 175 H.P. up to 200,000 lbs. per hr.

Other advantages that cut fuel bills and boost boiler room operating efficiency include: fully protective mechanism, accessible without tools; simple controls; water cooling; long-life grates with power dump, and many more features. The new descriptive bulletin "More Steam at Lower Cost" will be sent on request. Write American Engineering Co., Philadelphia 25, Pa.

AE Announces New Car Puller

American Engineering Co., Philadelphia, manufacturers of Lo-Hed Electric Hoists, announces the introduction of their new Class 2½ Lo-Hed Car Puller—affectionately called the "One Man Gang."

The Lo-Hed Car Puller is a husky hauling device in which the barrel, gear box and motor are integrated in a single, streamlined unit. Starting line pull is 5000 lbs., using a single line, or more with various block combinations.

Uses of the car puller range from hauling railroad cars of all types to pulling skids, powering boat and airplane runways, dragging logs, bending pipe and numerous other back-breaking operations where imagination sees its possibilities.

Dimensions, features and applications for the Lo-Hed Car Puller are presented in a colorful folder just released, and available by writing to American Engineering Co., Philadelphia 25, Pa.

New High-Quality Slide Rule Announced by Bruning

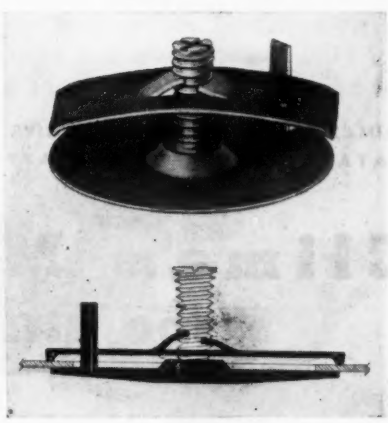
To fill the need for a high-precision, high-quality pocket slide rule which could be offered to engineers at a moderate price, the Charles Bruning Co. of Chicago has just announced its new Bruning 2401, 5-inch Pocket Slide Rule.

In introducing this slide rule, the Charles Bruning Co. stresses the fact that this is not a "duration substitute," but rather a carefully made, smooth-working precision instrument designed for fast, easy operation.

A notable feature of the slide rule is the precision of its graduations. These graduations, being molded in, are an integral part of the rule—will not lose visibility through use. Graduations and numerals of the CI scale are in red to facilitate reading. Three screws in the back of the rule provide a simple adjustment for tension on the slide. The indicator is of glass and is easily replaceable in the event of breakage. This indicator is enclosed in a frame of stainless steel that holds it firmly in place and eliminates "wobble." A, B, CI, C, D, K, S, L and T scales are shown on the rule in order to adapt it to the widest possible range of service. The beveled edges of the rule are in graduated scales of both inches and centimeters.

Officials of the Charles Bruning Co. say the slide rule will sell for under $4.00, complete with natural leather case and instruction booklet.

New Cover Plates



New Speed Nut Cover Plates were first designed for patching bullet holes in airplanes; now their industrial applications include removable covers for inspection doors,

Continued on Page 29

The predictable, minimum distortion characterizing molybdenum carburizing steels helps reduce the cost of producing precision parts

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

ARMY E NAVY

MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

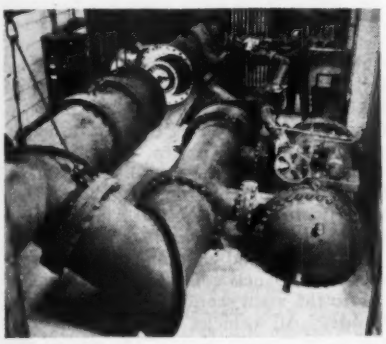
Climax Molybdenum Company

500 Fifth Avenue • New York City

MOLY

access holes and vent holes. They are also used to seal up holes left after alterations or removal of equipment. Easily and quickly attached from one side by sliding one end of the Speed Nut into the hole, centering the cover plate over the hole and tightening the screw. The turned-down tab on the cover plate prevents the Speed Nut from turning while the screw is tightened. To remove . . . just loosen the screw and slip the Speed Nut out of the hole. Made of SAE 1060 steel, heat treated, Parkerized and coated with Zinc Chromate Primer. Three sizes now available to fit a wide range of panel thicknesses and to cover holes $^{21}/_{32}$, $1^{1}/_{8}$ and $1^{3}/_{8}$ diameter. Other sizes are made on special order. Manufactured by Tinnerman Products, Inc., 2124 Fulton Road, Cleveland 13, Ohio.

High Pressure Wind-Tunnel Speed Turbine Blade Tests



A new type of wind-tunnel tests the blades of Westinghouse turbines many times faster than is possible with earlier tunnels. The wind tunnel used heretofore provides information on the aerodynamics of blades under high-gas velocities and gives the exact, accurate answers needed for final designs. However, because the models are subjected to high velocity they must be carefully made of steel. The wind-tunnel itself is massive, and requires a great deal of power to drive it. As a result seldom can a half dozen tests be made in a year with it. Because the new tunnel, on the other hand, tries the blades at low speed but in a medium of high pressure (220 pounds instead of atmospheric), the models can be fashioned of wood. Variations in shape and position can be tried in a few hours instead of weeks.

This type of testing is possible because the air-flow data is acceptably accurate if the pressure is increased as the speed is decreased, in such a ratio that the factor known as the Reynolds number is unchanged. For velocities well below that of sound (i.e., where compressibility is not a factor) the results obtained with the high-pressure tunnel are reasonably accurate, certainly within limits required in the preliminary stages of a blade or nozzle study. This allows a great many variations to be tried quickly, greatly expediting the final designs, which can be tested by the slower, but more precise high-speed tunnel.

6" Flexible Stainless Steel Tubing Now Available

Chicago Metal Hose Co., Maywood, Ill., announces the addition of a 6" I.D. size to its line of Rex-Flex Stainless Steel Flexible Tubing. Designed to meet many new requirements of both industry and aviation, this latest addition increases the range of available Rex-Flex sizes from $^{5}/_{16}$" to 6" I.D., inclusive.

The new 6" size thus adds to this line of corrosion-resistant, liquid and gas-tight flexible metal tubing—making a total of 16 different sizes and 5 types of wall structure available.

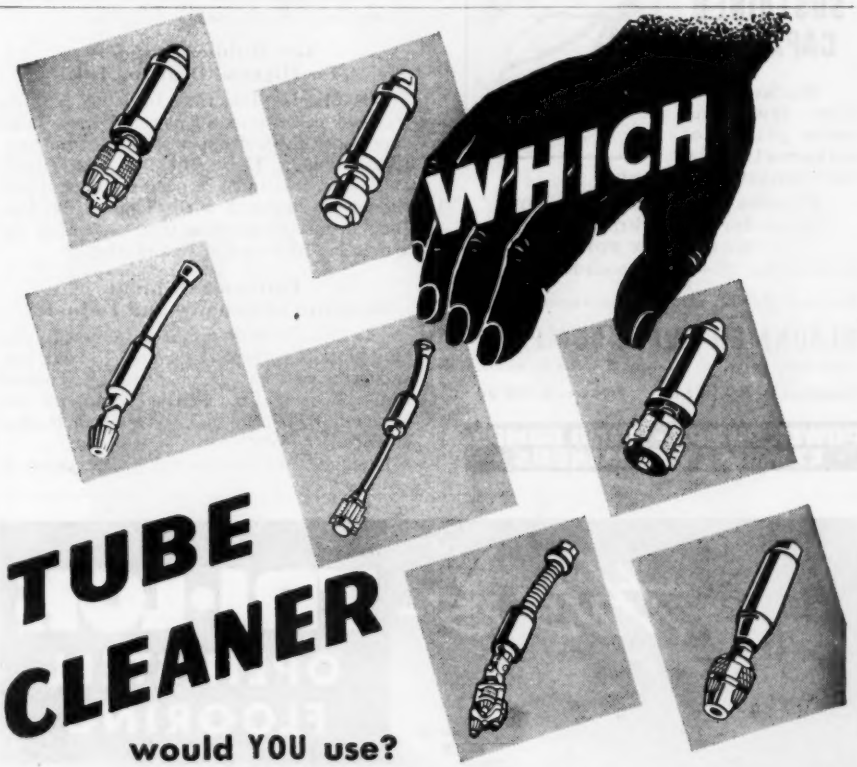
Rex-Flex stainless steel units are finding increasing favor throughout industry because of their non-corrosive, durable and pressure-tight characteristics. Also, Rex-Flex is bendable in multiple planes for easy installation and long flexing life.

Introducing "H.D." Clamped-on Tools for Heavy Duty Machining

Kennametal Inc., of Latrobe, Pa., is now producing a line of "H.D." tools having clamped-in and advanceable Kennametal tips, for heavy duty machining on steel castings, forgings, and bar stock, and cast iron. The H.D. design has been made possible by the development of heavy-duty Kennametal tips, that, while overhanging the tool shank by about $^{1}/_{16}$", have ample strength to take heavy feeds and depths of cut.

The special type of Kennametal tip used in the H.D. tool has a clamping shelf along the top of the side opposite to the cutting edge. It is diamond ground on the under side. When dull, the tip is advanced, and resharpened. The tip may be reground many times, since it is advanced to the front and side, in the oblique recess, until the major part of it has been utilized. Only the cut-

Continued on Page 30



TUBE CLEANER would YOU use?

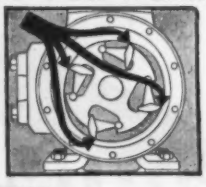
Do you have some special tube-cleaning problem—scale that's hard to remove, that involves too much cleaning time—trouble in getting the cleaner around short-radius tube-bends—damage to tubes being cleaned? If you have these or any other tube-cleaning difficulties, you should get a copy of the Wilson Tube-Cleaner Selection Guide. It will help you choose and use the best cleaner for each job—to get the job done faster and more economically. It has some worth while hints on how to reduce maintenance and make cleaners last longer.

A copy of the Selection Guide—and a 36 page bulletin describing a complete line of cleaners for practically every kind of deposit in all sizes of ferrous and non-ferrous tubes—will be sent upon request and without obligation.

wilson

THOMAS C. WILSON Inc.
21-11 44th AVENUE, LONG ISLAND CITY 1, NEW YORK

DEPENDABLE PUMPS for
DEPENDABLE MACHINES & PROCESSING EQUIPMENT
BLACKMER ROTARIES
are
SELF-ADJUSTING FOR WEAR
SUSTAINED CAPACITY



"Bucket" design (swinging vane principle) automatically compensates for wear.

20 years of service is not unusual for a Blackmer pump
WRITE NOW FOR
Bulletin No. 306—Facts about Rotary Pumps
Bulletin No. 302—Pump Engineering Data
BLACKMER PUMP COMPANY
1920 Century Ave. Grand Rapids 9, Mich.
Capacities to 750 GPM Pressures to 500 psi
POWER PUMPS · HAND PUMPS · EZY-KLEEN STRAINERS ·

• Keep Informed . . .

ting edge is ground, and no steel is removed in the process. The recess in the hardened steel shank is finished plane and true with a Kennametal-tipped fly cutter, or a Kennametal end file. The clamp and set screw, positioned to avoid abrading, permit smooth, unimpeded chip flow.

Use of Kennametal H.D. tools permits minimum tool stocks, since one shank serves for the life of many tips, and the proper grade of Kennametal tip can be used for each job. Heavy-duty Kennametal tips are available in Grades KM and K3H for general steel-cutting, Grade K2S for machining steel castings where scale is encountered, and Grade K6 for cast irons. H.D. tools are made in several styles, in the larger sizes, i.e., with shanks 1" wide, or more.

New Rubber Stoppers for Higgins Drawing Ink

The Higgins Ink Co., Inc., has recently received permission to manufacture a small supply of rubber dropper stoppers from synthetic rubber. These will soon be available and those draftsmen in need of the stoppers should get in touch with Higgins Ink. Co., Inc., at once mentioning that they read the article in "Mechanical Engineering."

Timken Exhibit at Museum of Science and Industry

The first dioramic display, the first to employ motion in three elements—on land, sea, and in the air—has been built by The Timken Roller Bearing Co., Canton, Ohio, for the Museum of Science and Industry in Rockefeller center, New York.

Designed and constructed by Messmore & Damon, specialists in New York, the display shows a landing scene on the Normandy coast. In the immediate foreground, a row of tanks, guns and armored vehicles travel from right to left across the beachhead, while more streams of mechanized equipment pour from the ramps of three LST boats offshore.

All vehicles are built to scale and are authentic reproductions especially built for the display. In addition to being actual scale models they are likewise made to conform to the rules of perspective, becoming smaller as the distance from the foreground increases. The LST boats rest on the beach and directly back of them is a display of water with waves rolling shoreward. This wave motion is effected through a system of rollers which synchronize with rocking ships placed between the rollers.

Airplanes, suspended from the top on invisible wires, are made to seem to fly by having the background move from left to right. There is a full cycle of lighting effects from the rose-colored tints of early dawn to full daylight; from the blueish tones of twilight to full darkness covered in a three-minute cycle.

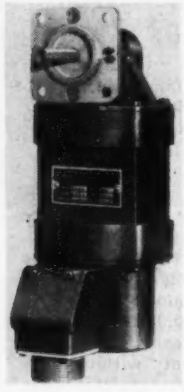
A brief message covering the four principle contributions of the Timken Co. to the war effort are shown in the translite panels on each side of the landing scene. These cover Timken Bearings, Timken Steel and Seamless Steel Tubing, Timken Rock Bits, and the Timken method of manufacturing gun tubes. Small panels containing bearings are built into the main section of the display on each side. All vehicles were built in the Messmore & Damon plant. The wheels are individually cast and operate on machined axles pivoted in the center so that they follow realistically the uneven road surfaces.

The company name and title of the display are cut-out wood letters, mounted in channels and indirectly lighted, while the entire front of the display is paneled in beech with a walnut trim.

For strength and simplicity, only two parts are used — bearing bars which carry the load and have curved slots punched ABOVE THE NEUTRAL AXIS, and cross bars, of the same cross sectional area as the slot itself, pressed into these slots to distribute the load. No rivets, bolts or welds are required, thus eliminating the possibility of loose joints. Tri-Lok flooring comes in rectangular, diagonal and U shapes with Safety Steps — ask for Bulletin 1140 — DRAVO CORPORATION, NATIONAL DEPARTMENT, 300 Penn Avenue, Pittsburgh (22), Pa. (Distributor for THE TRI-LOC COMPANY)

DRAVO

Angle Blower Drive Unit



Fractional horse power electric motor drive unit made by Electrical Engineering & Mfg. Corp., 4606 West Jefferson Blvd., Los Angeles 16, Calif., specifically designed for cabin heater drive in the Army's newest and fastest attack bomber, the Douglas A-26.

Light weight, continuous duty type, 1/2 hp, fan cooled, 7000 rpm motor equipped with right angle gear box and drive shaft. Gear ratio of 1 to 1. Overall efficiency of 70 per cent. Motor frame number 6220. For use in a 28 volt system. This self-contained unit engineered to fit in restricted space within existing airframe structure.

Complete motor type catalog, "Custom Built Motors for a World of Needs" now in preparation. Will be distributed on written request.

Double Reproduction Advantages with New Bruning BW-Copyflex Printer

New reproduction advantages—as well as double utility—are offered by a new machine recently announced by the Charles

• Keep Informed

Bruning Co. of Chicago. This machine, the BW-Copyflex Model 2 Continuous Printer, makes it possible to duplicate anything drawn, typed, printed or illustrated, as well as to make BW Prints . . . providing complete reproduction facilities for any type of industry or business.

This BW-Copyflex Continuous Printer exposes, with the use of Copyflex materials, tracings, line drawings, specifications, Van Dyke negatives, blue prints, etc. Original material with copy on both sides can be reproduced on either side or both sides Copyflex Prints are developed in trays and dried in a simple drier (readily available). With the flick of a switch, the Model 2 becomes a BW Printer for exposing Black and White Prints. Another new Bruning machine—the Model 153-M BW Developer is used for developing BW Prints exposed on the Model 2. Prints are delivered ready for use.

Compactly designed, the Copyflex Printer fits in desk-top space. It exposes roll stock or cut sheets up to 24 inches wide at a speed of 5 inches to 30 inches per minute. Because it is a continuous printer, speed of reproduction is considerably increased.

With the Bruning Model 153-M BW Continuous Developer, even an inexperienced operator can at once develop Black and White Prints in sufficient quantity for the moderate user. The machine develops cut sheets or roll stock up to 24 inches at a speed of 12 feet per minute. Like the Model 2 Printer, the 153-M Developer is built with exceptional compactness.

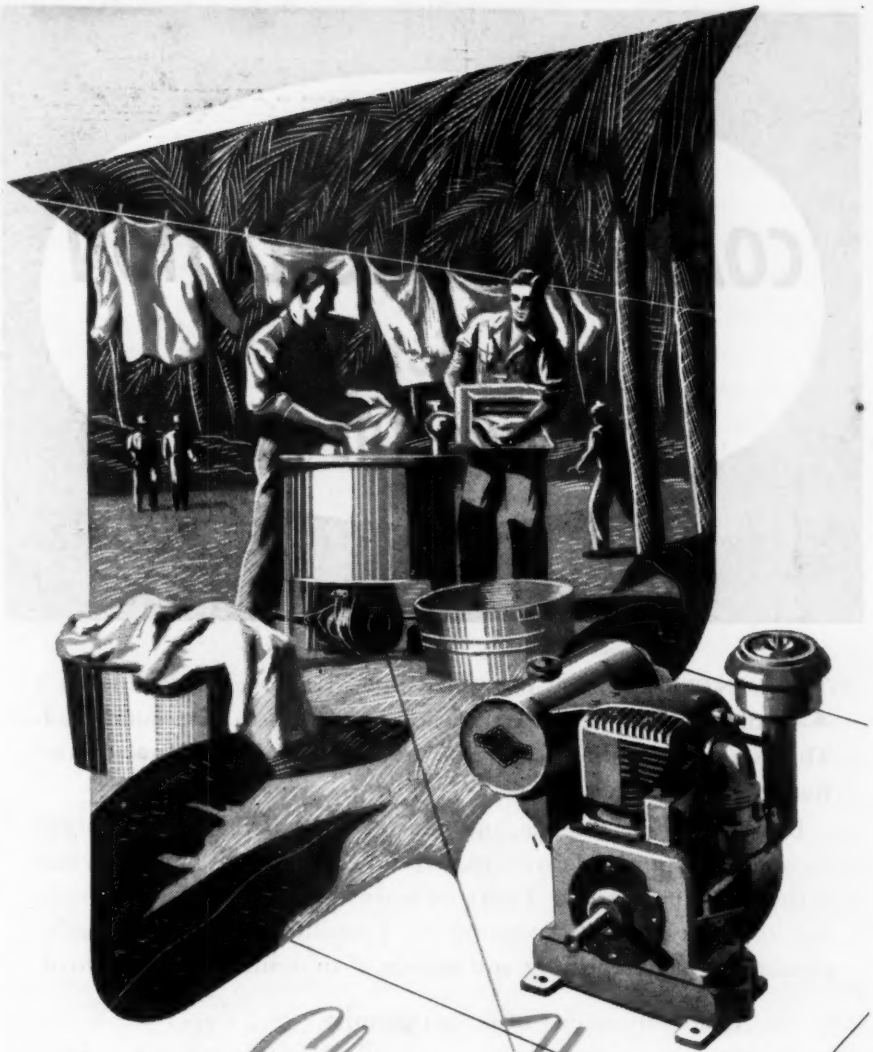
New Industrial Timer

A new manually preset interval timer, having exceptionally wide application has been announced by the Paragon Electric Co. of Chicago, Illinois.

The new model #2500 can be preset to allow a given operation to continue for almost any predetermined time limit; and to close or open a circuit at the end of the preset time.

This unit is particularly well adapted for use in plastic molding, rubber curving, batch mixing, heat treating, enamel baking, liquid agitation, light exposure, blower, pump, and conveyor operations, watchman signals, food cooking, power and light disconnect, machinery operation, control of ventilating fans on a preset schedule and night heating shut down.

Continued on Page 32



Cleaning Up on All Fronts!

Our fighting men are doing a double "clean-up job" on all fronts. To combat dirt and disease they use modern washing machines powered by trouble-free, air-cooled Briggs & Stratton gasoline engines — one more service for hundreds of thousands of Briggs & Stratton engines, now "humming" away for Victory.

Air-Cooled Power

4 CYCLE BRIGGS & STRATTON GASOLINE ENGINES

Manufacturers, distributors, dealers, and users of all types of appliances, tools, and equipment requiring dependable, compact power units vouch for the performance record of Briggs & Stratton engines. The latest models are backed by the experience gained in twenty-five years of *continuous* production of more than 2,000,000 *Air-Cooled* Gasoline Engines. BRIGGS & STRATTON CORP., Milwaukee 1, Wis., U.S.A.

This boiler is in COMPLETE CIRCULATION before STARTING THE FIRE

ENGINEERS quickly recognize the advantages of operating a boiler that is in full circulation from zero to maximum load. This is an outstanding feature of the International-LaMont Forced Recirculation Boiler.

Before starting the fire, and continuously thereafter, the forced recirculation pump, delivers to each tube many times as much water as the tube can evaporate. Each tube is always, therefore, wet throughout its entire length, preventing any possibility of unstable "flash" conditions or overheating and scaling of tube surfaces at any load.

Other advantages of design permit:

Higher efficiencies due to maximum radiant heat absorbing surface in furnace water-walls and effective arrangement of secondary heating surfaces.

Extreme flexibility—follows swinging load from no load to maximum load instantaneously.

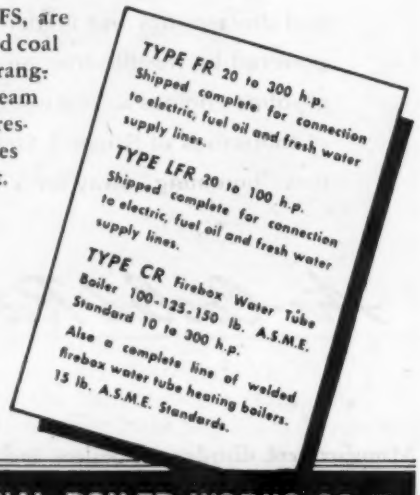
Steady water line and dry steam under all load conditions.

Minimum space requirements—low headroom a feature.

International-LaMont Boilers,* Type LFS, are designed for firing with oil, gas, pulverized coal or stokers. They are available in sizes ranging from 4,000 to 30,000 pounds of steam per hour and in all standard working pressures. Larger sizes and special pressures or superheat requirements on request.

Write today for bulletin illustrating and describing special features of this Type LFS Boiler.

*Licensed under LaMont patents.


TYPE FR 20 to 300 h.p.
Shipped complete for connection to electric, fuel oil and fresh water supply lines.
TYPE LFR 20 to 100 h.p.
Shipped complete for connection to electric, fuel oil and fresh water supply lines.
TYPE CR Firebox Water Tube Boiler 100-125-150 lb. A.S.M.E. Standard 10 to 300 h.p.
Also a complete line of welded firebox water tube heating boilers. 15 lb. A.S.M.E. Standards.

Boiler Builders for 59 Years

THE INTERNATIONAL BOILER WORKS CO.
POWER DIVISION
260 BIRCH STREET · EAST STROUDSBURG, PA.

• Keep Informed

Engineered features are: (1) Switch—single pole, double throw 1,000 Watt capacity, fully enclosed. Underwriters approved. (2) Only 2 exposed gears—motor pinion and wheel, precision hobbed. (3) Motor—self starting, slow speed, industrial type synchronous, completely sealed. (4) No energy is required of clock motor to trip switch at end of preset time. (5) Ten time ranges from 0 to 15 seconds through 0 to 20 hours. Available in all types of enclosures. (6) All parts rust proofed and protected against corrosion.

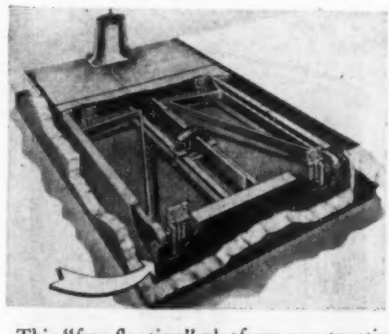
The 2500 series can be mounted to the surface of any panel or directly to the surface of the equipment the timer is to control. It is also designed to be mounted directly over and to any standard single gang switch box or handy box. Available for flush mounting or wall mounting with conduit connector.

Overall dimensions of the 2500 series are $4^{7}/_{8}$" high x $3^{1}/_{16}$" wide x 2" deep.

Complete details may be obtained by writing the Paragon Electric Co.

Platform Construction Increases Weighing Accuracy

Kron Platform Scales, of both open construction and self-contained types, are built on a "free floating" principle and are designed to assure correct weight regardless of where the load is placed on the platform. Equal load distribution, spreading the same weight through all four platform corners, permits a hand lift truck, skid, pallet or any other load to be positioned on any part of the platform at no sacrifice in accuracy. This advantage not only cuts weighing costs, but it also speeds up weighing time since the load need not be centered on the platform in order to obtain a true weight reading.



This "free floating" platform construction prevents lateral platform motion from being transmitted to the platform lever system. It absorbs all swinging motion and results in pivot and bearing wear only when a load is actually weighed. In addition, this construction eliminates binding and friction, thus lengthening pivot and bearing life and lowering maintenance and replacement costs.

The self-contained dormant platform is extremely shallow and will fit into floors of wood, metal, composition or concrete requiring a minimum of depth. This is made possible by the method of suspension with the main platform levers being in the same plane.

The open construction dormant platform is built on a structural steel "H" frame on which the entire lever system is mounted, keeping all corner fulcrum supports in permanent alignment. Both self-contained and open construction types of Kron dormant platform scales can be shifted from place to place without damage or loss of accuracy.

All upper and lower platform frames are constructed entirely of structural steel plate and shapes permitting great strength in a minimum of space. Lever, fulcrum and leg castings are normalized and well seasoned before being machined, free of stress and distortion. Pivots and bearings are made of

• Keep Informed

special analysis steel alloys, ground to exacting limits. All pivots, bearings and loops are given a plated coating to prevent corrosion.

Kron Scales are available for weighing, counting, batching, testing, measuring. A catalog of models is available through the maker, The Yale & Towne Manufacturing Co., Philadelphia Div., Philadelphia 24, Pa.

100 Per Cent American Jet Engine

The first jet propulsion engine in this country free from foreign influence, is under development at Westinghouse for the Bureau of Aeronautics, Navy Department. When the development is completed, this new engine is expected to produce more pounds of thrust for a given amount of fuel and pounds of weight than any engines brought from Europe for study. This engine is expected to be important for future aircraft service.

Few subjects in recent years have been studied so assiduously, few have commanded so much research work, so much laboratory experimentation as gas turbines, of which jet propulsion engines are but one form. Actually an enormous amount of ground has been covered. Probably more has been accomplished in the past two years to make the gas turbine widely practical than in all previous history.

Essentially, work of three sorts is being done. One is in the field of high-temperature metallurgy, because the success of the combustion gas turbine cycle depends on the temperatures in the turbine itself being 1200 degrees F or more, which is well beyond the highest steam-turbine temperatures. The higher the allowable temperatures the greater the efficiency and the wider the field of usefulness of the gas turbine cycle as a prime mover.

A second and the most active phase of the activity is the design, building and testing of different units with many variations as to size and arrangement. This includes designs for the three main components of a gas-turbine cycle—axial-flow compressor, combustor, and gas turbine—and the relatively few but important controls and auxiliaries.

A third activity—sharply limited by more pressing war work—is the investigation of possible uses of the combustion gas turbine cycle. This involves extensive thermodynamic and heat-balance calculations for a wide variety of simple open-cycle systems, heat-recovery open-cycle systems, and closed-cycle systems all predicated on assumed efficiencies, loadings, and costs.

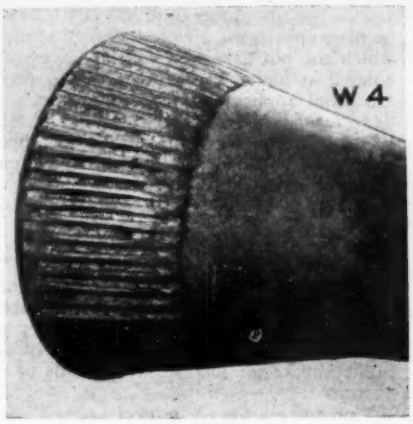
The great attraction of the combustion gas turbine cycle lies in its simplicity, its independence of a water supply. Basically it consists of three units on a single shaft. Liquid fuel is burned with a great excess of air in a combustor. The hot products of combustion drive a gas turbine and, in the simple cycle, exhausts to atmosphere. The turbine develops power to drive an axial-flow compressor on the same shaft that supplied air to the combustor. Power from the turbine in excess of that required by the compressor can be utilized to drive a generator or some other mechanical load.

The efficiency of a 1200-degree F simple open-cycle gas turbine plant is about 20 per cent, which is only about two thirds that of a good steam or gasoline-engine power plant. Also all present combustors and turbines require liquid fuel. The unit, furthermore, is not self-starting. But it is simple in form, is small in weight and bulk, requires no water, and is a rotating device. Efficiency can be increased 10 or 15 per cent by adding various heat-recovery devices such as intercoolers for the compressor, regenerators for the com-

Continued on Page 34

Saving Metal, Money and Time *With Conservation Welding*

Incidental to war production an increasing number of worn ferrous equipment parts—the sort which used to be summarily

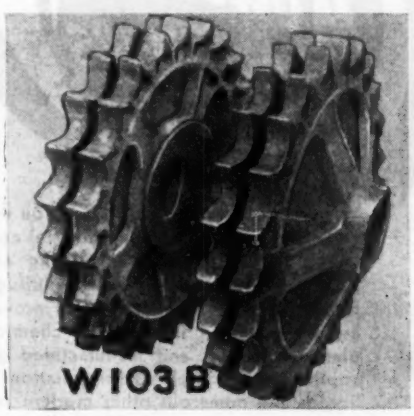


W-4. A rehabilitated manganese steel 128" crusher mantle. Amsco Nickel-Manganese Steel Filler Bars were swaged by hand to produce the proper contour, and were tacked onto the mantle, using Amsco Nickel-Manganese Steel Electrodes. Each bead was peened thoroughly. Total rehabilitation cost was $275.00.

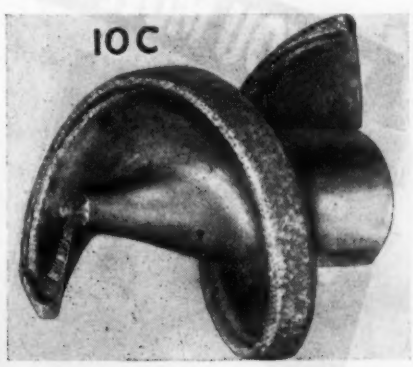
scrapped — have been salvaged for further useful life with Amsco Welding Products. This practice has saved large amounts of scarce metals and obviated the difficulties and delays attending the procurement of new parts. At the same time, many additional establishments have become familiar with the substantial reductions in replacement costs afforded by Amsco Conservation Welding.

Worn equipment parts which have been restored with highly wear-resistant Amsco welding materials often give as long service as new parts, and at considerably less cost. Substantial savings have also been obtained by hardsurfacing new parts with Amsco Welding Products which, having far higher wear resistance than the body metal, afford greatly increased service life. As replacement costs will assume added importance in the postwar period, *conservation welding* will be still more widely practiced.

A few examples of Amsco Conservation Welding are pictured. Others, with full information on Amsco Welding Products, are shown in Bulletin 941-W. Send for your copy.



W-103-B Sprockets from a tractor which were put in service at the same time. The one on the left had been rebuilt with Economy Hardface; the one on the right was a brand new sprocket. Note that the new one is worn to such an extent that it was necessary to resurface it with Economy Hardface, while the welded sprocket needed no repairs whatsoever.

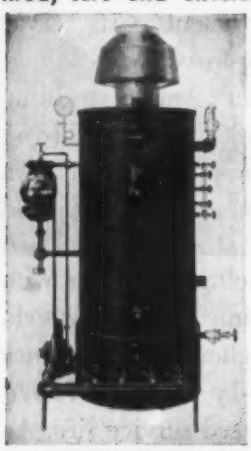


10-C This brick machine auger tip served over a year after being built up with Amsco Nickel-Manganese Steel Rod and hardsurfaced with Amsco No. 459 Rod, as compared to the usual performance of only a few months before replacement. A new part costs $45.00. Total salvage cost was $31.00.

Amsco
AMERICAN MANGANESE STEEL DIVISION
Chicago Heights, Illinois
AMERICAN Brake Shoe COMPANY
FOUNDRIES AT CHICAGO HEIGHTS, ILL.; NEW CASTLE, DEL.; DENVER, COLO.; OAKLAND, CALIF.; LOS ANGELES, CALIF.; ST. LOUIS, MO.
OFFICES IN PRINCIPAL CITIES

The KANE *Boiler* . . . at Work Today in Essential Industry

Many war plants depend upon the scientifically designed KANE boiler for an independent source of process steam. This unit—automatic, gas-fired, safe and efficient—is built to A.S.M.E. Code in sizes up to 30 H.P., 100 lb. pressure is standard—higher pressures can also be supplied. It has long been the choice of many leading engineers.



MEAKES-KANE-OFFELD
Manufacturers of Automatic Steam Boilers for over a third of a century
1903-1915 EAST HAGERT STREET, PHILADELPHIA 25, PA.

• Keep Informed . . .

bustor, and fuel reheaters. These, on the other hand, add complications and some demand a supply of cooling water.

It is expected that open-cycle units with approximate maximum ratings of 7500 hp will be useful as emergency or stand-by generating units on power systems, particularly at the end of long lines or where good or adequate boiler water is lacking. To obtain larger amounts of power for central station use from units of practical size, it will be necessary to use a closed-cycle system, in which the hot gases are continuously recirculated at higher pressure. Certain special industrial applications look promising, such as to furnish power for blast furnaces. Also the gas turbine is attractive for ship propulsion and for electric-drive locomotives, particularly because of the water economy.

New Type All-Purpose "Protectioneered" Motor Announced

Following months of research and practical operation in the field, Fairbanks-Morse has now announced a New type, All-Purpose, Continuous-Duty, Polyphase Squirrel-Cage Induction Motor for use in all kinds of industry.

This new motor is "protectioneered" and according to the company, embodies many special and vital features that will be viewed with extreme interest by motor users everywhere.

Constructed with the widely recognized and exclusive centrifugally-cast F-M Copperspun Rotor, this new motor is fully protected against flying chips, falling particles, dripping liquids, and other industrial motor hazards. The ball bearings sealed in cartridge-type housings minimize expensive shut-downs due to bearing failures. Cross-flow ventilation, a feature in frames 224 to 365 inclusive, is obtained through protected inlets and exhausts at each end of the motor—resulting in uniform cooling and the elimination of hot spots.

Regardless of the position of the motor, complete safety for the operator is assured because there are no moving external parts. The frame is cast in one piece with rib sections to give added strength without increase in weight.

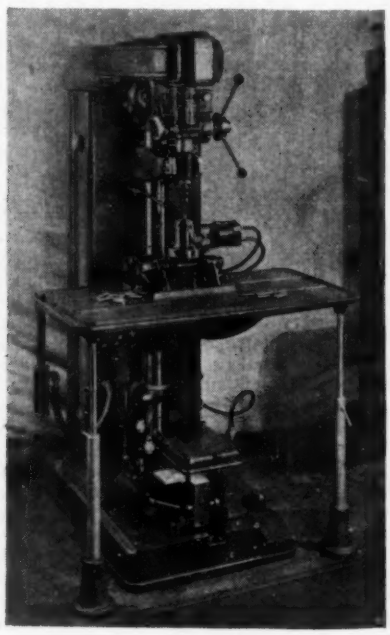
The new motor also incorporates an innovation in conduit boxes. Where space is limited, the conduit can be brought up between the motor feet to the tapped hole in the motor frame and the conduit box cover assembled flush with the frame. The external box is then discarded. When the conventional conduit box is used it can be mounted in any one of four positions.

It is rated 40° C and designed to carry 115% load continuously without injurious heating (1.15% service factor).

Complete information and motor demonstration can be obtained by getting in touch with your local Fairbanks-Morse representative or by writing to Fairbanks, Morse & Co., Chicago, Ill., for Bulletin #1160 which features this new F-M motor.

Unique Zagar Fixture Set-Up

A standard "Zagar" Air-O (Air-operated) Holding Fixture in conjunction with the new Warner & Swasey Precision Tapping and Threading Machine turns out one piece every three seconds—a remarkable increase in production.



A special mounting by Warner & Swasey tips the fixture about 20 degrees for loading and unloading, thereby saving the time that would be consumed in raising the spindle more than an inch above the work.

The operator merely steps on a treadle, which tilts the Holding Fixture to load. When the treadle is released the fixture is returned to the vertical position by means of a spring.

A micro-switch then starts the operating cycle. When the cycle is completed the machine stops.

Automatic valves were installed at the control box to open and close the collet when

IF YOU MOVE AIR OR GAS at Moderate Pressures

—write for Bulletin 120-B-12. You will find the engineering information contained in its 20 pages interesting and helpful. Roots-Connersville Centrifugal Blowers and Exhausters have proved highly successful in refinery, chemical plant, steel mill, and manufactured gas applications, as well as for agitation of liquids and numerous other modern services. Your copy of this bulletin is ready.

ROOTS-CONNERSVILLE BLOWER CORP.
One of the Dresser Industries
502 Michigan Ave., Connersville, Indiana

Roots CONNERSVILLE SINCE 1854 Centrifugal EXHAUSTERS and BLOWERS

• Keep Informed

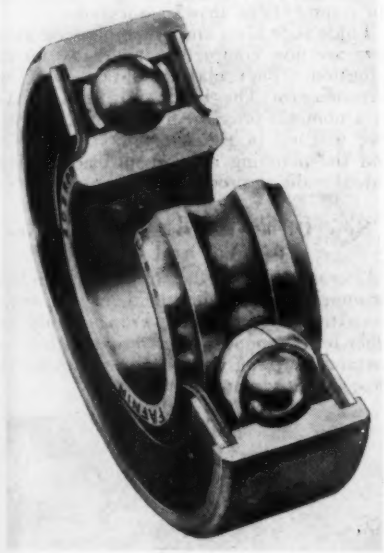
the fixture is tilted for loading and unloading. Air pressure is used only to operate the opening and closing mechanism. Fluctuation in air line pressure does not affect the holding power of the fixture.

This "Zagar" Air-operated fixture uses standard 14 AC No. 2 collets. A most important feature is that the collet does not move vertically in closing. Consequently, the work can be held to close tolerances in second operations, such as milling slots on a milling machine, drilling and tapping to a given depth, counterboring or spotfacing on a drill press, etc. There are provisions for a stop in the fixture to insure duplicating of parts.

Address all inquiries to Zagar Tool, Inc., 23880 Lakeland Blvd., Cleveland 17, Ohio.

New Bearings Offer Positive Sealing in Standard Widths for First Time

The Fafnir Bearing Co., New Britain, Conn., is offering an entirely new type of sealed ball bearing. Known as "Plya-Seal," the sealing element consists of a diaphragm-type, contact seal comprising two members—a flat, flexible sealing washer of synthetic rubber-impregnated fabric and a split retaining ring of spring steel. Due to the minimum space required for the two seal parts, Plya-Seal bearings, except in the extra-small sizes, are held to the same widths as standard unsealed bearings. The standard width of the Plya-Seal bearings enables them to be used in applications where shielded bearings previously used were inadequate for the service.



Firmly held in the outer ring, the sealing washer does not rotate with the inner ring but is in contact with a ground groove to form an effective seal with a minimum of friction.

The Plya-Seal can be easily removed and replaced to allow inspection, washing, and re-greasing of the bearing—a feature which makes it possible to use Plya-Seal bearings in many applications where heretofore a pre-lubricated and sealed bearing could not be employed because service conditions necessitated re-lubrication during the useful life of the bearing. This is especially desirable in applications where periodic overhauls of equipment are standard practice.

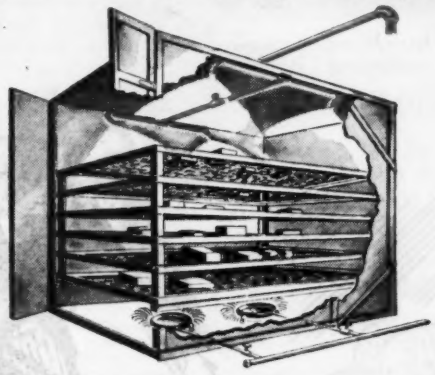
Performance in service has proved that Plya-Seal assures maximum retention of lubricant and maximum exclusion of dirt and

Continued on Page 36

"Automatic" vs Stubborn

FIRE-FOG DRYER FIRES

-a Fire Test of Interest to Every Manufacturer



Automatic FIRE-FOG ★ IT BLANKETS ★ IT ISOLATES ★ IT QUENCHES ★

The Time: Summer, 1944.

The Place: "Automatic's" Test Yard, at Youngstown, Ohio.

The Occasion: A test to determine the fire protection value provided by FIRE-FOG for a Dryer.

Frankly, FIRE-FOG was "on the spot"—other fire protection methods had failed.

Conditions at the manufacturer's plant were simulated. A test oven was built; drying racks were made; pieces of material distributed over the racks. Gas burners were lighted and the temperature brought up to the ignition point for the material tested and maintained for 15 minutes—*then* FIRE-FOG was introduced into the oven through FIRE-FOG Nozzles.

The result?—in only a matter of seconds the fire was extinguished! And only a few gallons of water had been used!

What has "Automatic" to offer you? "Automatic" service includes test, design, manufacture, and installation of the type of sprinkler system best adapted to extinguish YOUR fires. Write for complete information.

NOTE: In normal fire-fighting operations FIRE-FOG action is entirely automatic—it blankets . . . isolates . . . quenches—usually in a matter of seconds.

"Automatic" SPRINKLER CORPORATION OF AMERICA

YOUNGSTOWN, OHIO . . . OFFICES IN 31 CITIES

liquids. The seal causes no distortion of the outer ring or race, so does not affect the concentric relationship of the inner and outer bearing rings.

Illustration shows the Plya-Seal disc wedged into the outer ring and maintaining perfect contact with the inner ring thus forming a positive seal. Seal is non-capillary and impervious to grease, oil, gasoline, water and a variety of solvents. Plya-Seals resist heat to a degree far in excess of the recommended limits for the use of a grease-lubricated bearing and are unaffected by sub-zero temperatures as well. Sealing washer does not deteriorate with age.

Plya-Seal bearings have been performance-proved in military equipment. Approved for aircraft by the Army Air Forces and the Bureau of Aeronautics, U. S. Navy. Successfully used also on many types of industrial machinery to completely eliminate former difficulties experienced with metal shielded or seal-type bearings.

A descriptive folder giving complete information on Plya-Seal Bearings is available from the manufacturer.

New Slide Films for Teaching Oxy-Acetylene Processes

An industrial teaching aid in the form of a series of how-to-do-it slide films and accompanying instruction literature on oxy-acetylene welding and cutting operations has recently been completed by The Linde Air Products Co., a Unit of Union Carbide and Carbon Corp. Carefully planned to be adaptable to streamlined wartime production as well as to the tempo of peacetime, to the needs of the beginner and the "old timer," the lessons are presented as a step-by-step procedure and cover the basic techniques of welding and cutting.

The lessons are arranged in series and are presented as follows: 1.—A "Cutting" series consisting of eight lessons on connecting, testing, and lighting the oxy-acetylene cutting blowpipe, and on making straight-line cuts. 2.—A "Welding" series in ten lessons showing how to connect, test, and light the oxy-acetylene welding blowpipe, and giving basic welding instructions for light plate. 3.—A "Safety" series consisting of one lesson on the care and handling of equipment and a second lesson on fire precautions.

The shop superintendent, foreman, safety supervisor, or welding instructor who must supervise such instruction will find in this program a well-planned course immediately available to his needs. Very often such a person, skilled in the proper techniques himself, can be helped by placing in his hands an effective aid for teaching these techniques to others. An instructor's manual with suggestions on accepted teaching procedures is provided and should prove particularly helpful to him. Each slide film comes with three of these instructor's handbooks, and 25 student handbooks, which contain a written record of the step-by-step procedures shown in the film. The film is a succession of pictures, in regular 35-mm. motion picture film that can be projected on a screen one at a time as still pictures, while the instructor comments or answers questions.

Linde slide films and accompanying literature are now completed and ready for distribution. They may be obtained through any office of The Linde Air Products Co. at a nominal price. Any Linde representative will aid in the selection of slide films and the planning and organization of individual training programs.

New Diesel-Electric Locomotives for War and Peace

Literally hundreds of American-built locomotives are hauling loads of war and of reconstruction in Africa, France, Italy and other battlegrounds. Indicative of their importance locomotives have been among the most sought targets for airmen.

With the needs of war-torn areas in mind a new diesel-electric locomotive developed by the Whitcomb Locomotive Co. using Westinghouse generators and motors proves to have many desirable features that are expected to appear in switching locomotives for service in our own railroad and industrial-plant yards. In the interests of weight, cost, and simplicity, exciters have been eliminated by the development of new self-excited generators, the largest ever built for railroad service. They are rated at 650 amperes, 305 volts, a pair comprising the electrical power plant. The generators are specially designed

FEATHER DUSTER METHODS
—won't do the job!

AAF Multi-Duty filters clean themselves as they clean the air. Send for Bulletin No. 241-A

An era of competition such as American industry has never before experienced will break like a bombshell when manufacturers return to producing civilian consumer goods. To be prepared to operate profitably in this new economy calls for careful consideration of all the factors that might result in lowering manufacturing costs.

AAF has the facilities TODAY to help you work out your tomorrow's dust control system now. There is no obligation involved in asking for help. Let us send you "AAF In Industry"—which describes the full line of AAF equipment.

AMERICAN AIR FILTER COMPANY, INC.
103 Central Ave. Louisville, Ky.
IN CANADA: Darling Bros., Ltd., Montreal, P.Q.

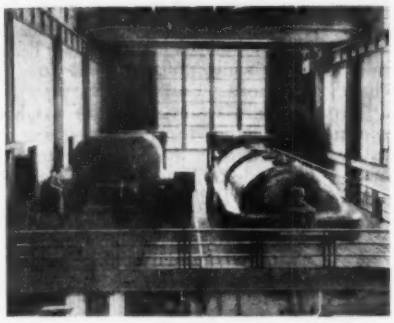
AMERICAN AAF AIR FILTERS

• Keep Informed

to provide inherent electrical characteristics, without the external excitation usually required.

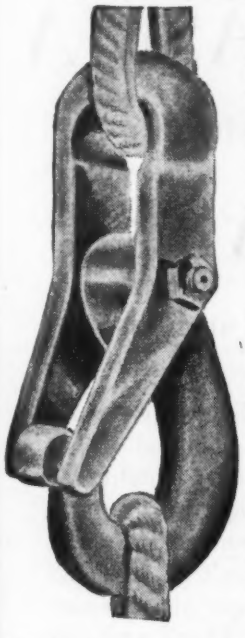
The motors are designed especially to match the generators. Four of these are used on each locomotive, one per axle, two being connected permanently in parallel for each generator.

Successful Operation of Burlington Turbine Indicates Possibility of Higher Steam Temperatures



Two-years successful experience with high-temperature turbine generators (950 degrees F.) such as the 125,000-kw three-cylinder unit built by Westinghouse for the Burlington Generating Station of Public Service Electric & Gas Co. of New Jersey makes designers willing to take the next step—1000 degrees F. The experience with the 50,000-kw 1600-pound, 940 degree superposed unit at Sherman Creek station of Consolidated Edison Co. of New York has been equally gratifying. A 50-degree rise in temperature of inlet steam means a gain of nearly two percent in overall plant efficiency.

Heavy Duty Hoist Hook



A heavy duty hoist hook that is just about the last word in safety has appeared on the market under Patent No. 2,359,557. The invention of an active engineer, this hoist hook safely handles loads up to 200 tons.

Robert Hoffman, the inventor, while engaged on such projects as the North Island Naval Base at San Diego, Pan-American Highway, etc., experimented with many types and designs of hoist hooks. His goal was a hook which would be proof against breakage, slippage, work stoppages and accidents to life and property. He firmly believes that this goal is reached in the new "Aclc" Hoist hook and leading American engineers agree with him.

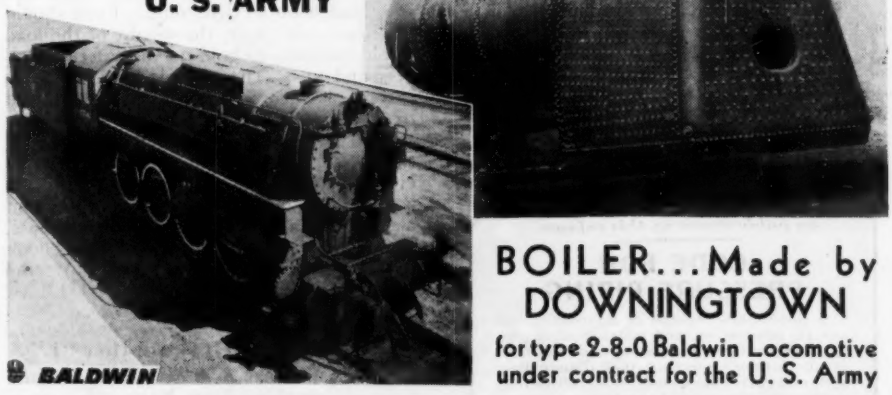
A single #2 "Aclc Safety Hoist Hook" weighs only 9½ lbs. yet it has a guaranteed capacity of 10 tons and has withstood without any ill effects a Columbia University Laboratory proof load test of 60,000 lbs.

Continued on Page 38

On . . . to Berlin!

DOWNINGTON

. . . with the U. S. ARMY



BOILER . . . Made by DOWNINGTON

for type 2-8-0 Baldwin Locomotive under contract for the U. S. Army

Under sub-contract for the Baldwin Locomotive Works, DOWNINGTOWN is fabricating boilers for U. S. Army locomotives. This contribution to the War effort, although a departure from our regular line, demonstrates Downingtown's versatility and is an example of the "out of the ordinary" jobs we are capable of turning out.

You may require a difficult type of fabrication utilizing steel, monel, iron, nickel or alloys of these or other metals. Whatever your problem, Downingtown engineers welcome the opportunity to work with you on it . . . a similar job may have gone through our plant . . . we can advise you promptly whether we can undertake the work and complete it satisfactorily and economically.

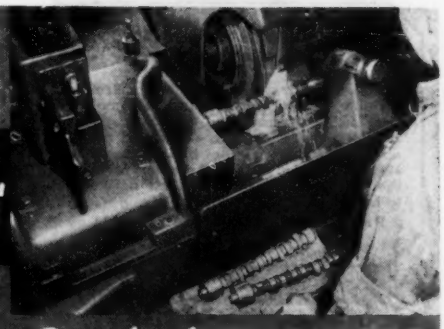
Thirty consecutive years in this business have built up our specialized knowledge of fabrication—have schooled us in the proper methods of procedure—which, coupled with our complete, modern plan facilities equip us to guarantee a safe and enduring piece of work, adequately delivering top performance and economical service.

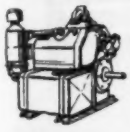
Our "Fabrication Book" will serve to further acquaint you with our capabilities—send for it.

Heat Exchangers—our new 24 page bulletin on the design and fabrication of heat exchangers should prove to be a valuable addition to your files on heat transfer equipment. Write for a copy . . . on your letterhead, please.

DOWNINGTOWN IRON WORKS
DOWNINGTOWN, PA.
WELDED and RIVETED PRODUCTS

PRECISION-GROUND CAMSHAFTS
Another
"HIDDEN VALUE"
IN ALL
WISCONSIN *Air-Cooled* ENGINES





The "Camomatic" is another of those more-than-human machines that help to put heavy-duty serviceability and smooth-running efficiency into every Wisconsin Engine.

This machine automatically rough-grinds (and subsequently "smooth-finishes") each and every cam for every Wisconsin Air-Cooled Engine. The grinding wheel finishes cam contour with absolute precision and uniformity. Every camshaft for a given size engine, is exactly like all the other camshafts for all the other engines of that size.

This is another of those features you *don't "see"* . . . but it performs an important service for you *on the job, on your equipment.*

Most H.P. per pound

WISCONSIN MOTOR
Corporation
MILWAUKEE 14, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines

BOOKS

20% Discount to A.S.M.E. Members on publications in this column.

CODE FOR PRESSURE PIPING

A dependable source of information on design, fabrication, and installation of piping used in steam generating and industrial plants; for conveying air; fuel, illuminating and non-corrosive gases; oil; refrigerant brine; and steam and hot water.

Published 1942 (B31.1) $2.00

MANUAL ON CUTTING OF METALS

A 320-page book for shop men, presenting tested data in tabular form from which speeds and feeds for metals in common use can be set for various depths of cuts. Time and horsepower necessary for a cut under stated conditions are also shown, as well as examples in the use of the data.

Published 1939 $5.00

SAFETY CODE FOR CRANES

A standard guide for the construction, installation, inspection, maintenance, and operation of cranes, and derricks driven by steam engines, electric motors, or internal combustion engines to their runways, to simple hoists, to overhead electric hoists and their runways, to overhead air hoists, and to hand-powered derricks.

Published 1943 (B30.2) $1.50

SAFETY CODE FOR ELEVATORS

Designed to insure safety in the construction, inspection, maintenance, and operation of all types of elevators, dumbwaiters, and escalators. Detailed recommendations are given for hoistways and enclosures, guides, buffers, counterweights, car construction and safeties, cable and signal systems, speed control, etc.; also for qualification and training of operators.

1937 Publication with 1942 Supplement (A17.1) $1.25

ELEVATOR INSPECTORS' MANUAL

Shows how to make a thorough and satisfactory inspection of all equipment involved from brake action, switches, stopping devices, speed, counterweight safeties, to control and operating equipment, car capacity, emergency exits and release, lighting, hoistway, elevator ropes, and rope sockets.

Published 1937 (A17.2) 75¢

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Publication Sales Dept.
29 West 39th St., New York 18, N.Y.

• Keep Informed . . .

Because it is carefully engineered for the purpose the "Aclc Hoist Hook" keeps hoist and load in true alignment, while the patented shoulder and lip eliminates load slippage and hook straightening. Even should the heavy pin shear, the weight of the load would continue to hold on the safety shoulders and lips. These self-locking shoulders and lips, incidentally, were carefully designed to clear hatches, cornices and other protuberances without snagging. Despite all these exclusive advantages, the "Aclc Safety Hoist Hook" costs far less than ordinary hooks. Although originally planned and made solely for use on his own assignments, Mr. Hoffman has arranged to have his hook manufactured and distributed by the American Chain Ladder Co. Inc., 151 East 50th Street, New York, N. Y.

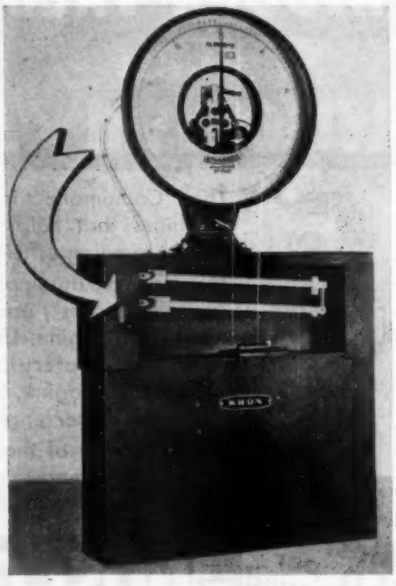
Chain Belt Receives Another "E"

The Chain Belt Co. of Milwaukee has just received another Army-Navy "E" star! This makes the fourth time that official commendation from Washington has been directed to Chain Belt. The company received its original Army-Navy "E" pennant award September 19, 1942.

In addition to the company's regular products which are widely distributed among other producers of war equipment and more essential civilian needs, Chain Belt Co. has produced since 1941 medium size howitzers, pack howitzers, 120 millimeter anti-air craft guns, field guns, refuse grinders for transports and landing barges, tank turrets, gun shields, traction shoes for amphibious landing craft and ammunition hoists for other Naval units.

High Weighing Capacity and Low Dial Graduations Featured in Kron Scales

The "Kron" Unit Weight Cabinet attachment answers industrial requirements for a high gross weighing capacity scale with low and accurate "fractional" weight dial chart graduations. This scale is equipped with the standard "Kron" dial mechanism, swivel head, tare and capacity beams and drop weights to provide the greatest gross platform capacity of any scale of its type.



The unit weight increment principle around which this scale is designed is simple and fool-proof. By rotating the handle on the left of the cabinet front (see illustration), from 1 to 7 unit weight increments, each equivalent to the dial chart capacity, can be added to the lever system to increase the gross weighing capacity of the scale. The weight increments are indicated in a target on the dial chart as they are added to the lever system. Flexible cables connecting this target to the drop weight mechanism allow the dial head to swivel to any desired position.

The outstanding advantage of the "Kron" Unit Weight Cabinet Scale to users requiring a high gross weighing capacity combined with accurate "fractional" weight readings is the ease, simplicity and precision with which the gross weighing capacity of this scale can be increased as much as nine times for heavy-duty service, while still retaining low dial chart graduations.

"Kron" Scales are available for weighing, counting, batching, testing, measuring. A catalog of models is available through the maker, The Yale & Towne Mfg. Co., Philadelphia Division, Philadelphia 24, Pa.

Third Army-Navy "E" for Briggs Clarifier

The Briggs Clarifier Co., Washington, D.C., designers and manufacturers of modern oil filtration equipment, has just received its third successive Army-Navy "E" award.

The company feels strongly its responsibility in handling the Army and Navy contracts and will continue to provide the needs of the armed services. It knows that any delay in delivering vitally essential oil filters can affect the lives of our fighting men.

Two brief ceremonies were held. In the morning of "presentation day", workers gathered in the new factory building to hear a short talk by a fellow employee, a veteran of recent air combat over Europe. In the

PLASMA

without

PAPER

is useless

You willingly give your blood to the Red Cross, but unless it is delivered to the fighting fronts it will save no soldier's life. And it can't be delivered without special paper containers. That's why you must save every scrap of waste paper from newspapers and magazines to letters and turn them into the salvage campaign.

• Keep Informed

afternoon, the ceremony was repeated at the business offices. At both gatherings, lapel pins were given to all employees entitled to wear them.

Briggs Oil Clarifiers are moving to our armed forces and to our allies at an ever increasing tempo. Already, enough have been manufactured to equip our entire Diesel powered merchant fleet, a formidable portion of our Naval vessels, as well as the requirements of industrial users for war purposes. Also, enough aircraft ground clarifiers have been produced to service a major portion of the fighters and bombers in the Army Air Corps. Hundreds of tons of precision engineered oil filtration equipment roll from Briggs factory doors every month and will continue in the direction of the armed forces as long as it is needed.

Welder of World War I Dwarfs Modern Unit

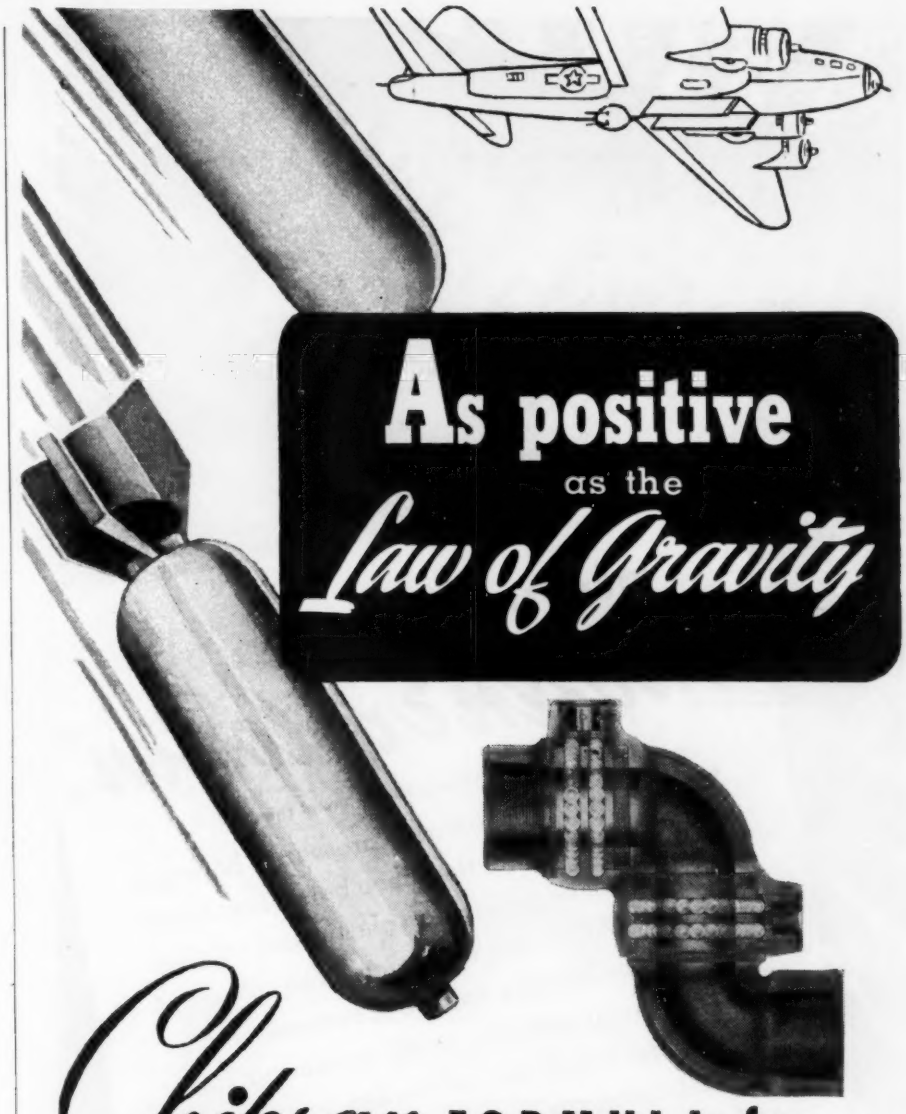
Evidence of how the art of arc welding has advanced at a pace consistent with other miracles of industry is graphically depicted in this comparison which shows a 400 ampere welder of 1917 (above) weighing about 3,500 pounds and priced at $2,000 with today's version (below) weighing only 1,200 pounds and costing slightly over $400. (Photo Courtesy The Lincoln Electric Co., Cleveland, Ohio.)

National Forge Among First Winners of 5th Star

The 5th White Star is now appearing on a very few Army-Navy "E" Flags. Among the first to receive this latest citation for sustained excellence in war production is the National Forge & Ordnance Co., Irvine, Warren County, Pa.

To be eligible for the 5th White Star a company must be engaged in continuous war production for at least three years and have received four previous white stars in addition to the basic Army-Navy "E" Flag. In the case of National Forge, their first "E" award came to them from the personal hands of the late Frank Knox, when he was secretary of the Navy. This award was made on October 24, 1941—six weeks before Pearl Harbor.

Continued on Page 40



As positive as the *Law of Gravity*

Chiksan FORMULA for a *Perfect* SWIVEL JOINT

BB2 = Double rows of Ball Bearings — For easy turning with minimum friction. They also maintain perfect alignment of moving parts.

EP = Effective Pack-Off — This self-adjusting unit permits the use of the same Swivel Joint for all services. Nothing to tighten or adjust.

LT = Low Torque — No excessive friction drag because turning takes place on ball bearings which hold moving members together. Tightness of Joint does not depend upon compressing packing element by means of bolted flanges, thereby causing joint to stick.

P/V = Pressure or Vacuum — Pre-determined pressure on Packing Ring prevents leaks due to pressure or vacuum. Packing automatically adjusts itself to either service.

These are the essential elements for perfect swivel action. You get ALL of them when you specify Chiksan Ball-Bearing Swivel Joints.

Write for Catalog and Engineering Data

CHIKSAN REPRESENTATIVES IN PRINCIPAL CITIES

Distributed Nationally By Crane Co.

CHIKSAN TOOL COMPANY

Ball Bearing SWIVEL JOINTS for ALL PURPOSES

BREA, CALIFORNIA

picture of a
"Frozen Explosion"*

* Photomicrograph of metal chip.

When metal is machined, pressures between the moving body of the piece being machined and the tool edge develop elastic and/or plastic forces *within the workpiece*. The release of these forces literally *explodes* successive portions of metal, sending them streaming forth in the form which we call a chip.

Metal-cutting is a matter of metal behavior and flow, in which complex process the cutting fluid regulates temperature, lubricates rubbing surfaces, prevents welding, and possibly dampens vibrations.

Stuart men are skilled in attaining the most favorable balance of these qualities in cutting fluids, both in the lab and on your machines.

For further information on the mechanics of metal-cutting, write for your free copy of Stuart's 60-page booklet, "Cutting Fluids for Better Machining."

D.A. Stuart Oil CO.
LIMITED
2741 SOUTH TROY STREET, CHICAGO 23, ILL.
ESTABLISHED 1865
Warehouses in Principal Metal-Working Centers

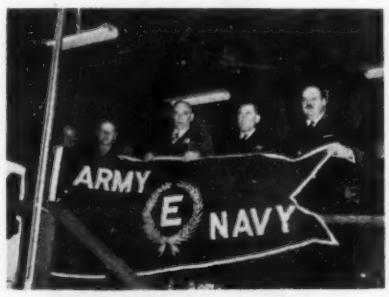
• Keep Informed

In advising president John C. Harrington that National Forge had merited the 5th Star Award, Admiral Bloch, chairman of the Navy Board for Production Awards, stated, "The Army and Navy congratulate the National Forge & Ordnance Company on being one of the first to be awarded a fifth renewal of the Army-Navy "E" Award. During the coming year the five stars on the "E" flag proudly flown over your plant will be proof to everyone that the National Forge & Ordnance Co. is continuing to do its utmost to assist the Army and Navy. The members of the Armed Forces highly appreciate the inspiring record which has been established by the untiring efforts of each and every man and woman in your plant."

Kieley & Mueller Receive a Second Star

A second star on its Maritime "M" pennant has been awarded to Kieley and Mueller, Inc., North Bergen, N. J., and its employees, according to an announcement by the Board of Awards of the U. S. Maritime Commission. This Award, highest production honor of the Maritime Commission was made, according to the Maritime Commission Board of Awards in recognition of the 66 year old company's outstanding production achievement in successfully meeting the urgent demand for valves and controls in the shipbuidling program.

Army-Navy "E" Presented to Goulds Pumps



Hailed for their outstanding achievement in the production of war materials, 900 workers of Goulds Pumps, Inc., Seneca Falls, N. Y. received the Army-Navy "E" award at an impressive ceremony held in the plant on December 14, 1944. Comm. Robert S. Smith, Jr., U. S. N., Inspector of Navy Material, Buffalo, presented the "E" flag to Mr N. J. Gould, President of the company, who accepted the banner in behalf of the workers. Col. Arthur D. Elliot, Commanding Officer, Seneca Ordnance Depot, presented Army-Navy "E" pins to three of Goulds oldest employees in point of service.

Illustration shows left to right: Wm. Wicks, employee representative, Col. Arthur D. Elliott, U.S.A. who presented pins, Mr. N. J. Gould, Pres. of Goulds Pumps, Inc., Comm. Robert S. Smith, Jr., U.S.N., who presented flag, Lt. Comm. John T. Casey, U.S.N.R., Master of Ceremonies.

Outstanding feature of the program was the unanimous vote of the workers to reply to a telegram of thanks from Secretary of the Navy Forrestal by pledging themselves to continue wirh renewed zeal and vigor the production of pumps so badly needed to make Victory certain.

Since before Pearl Harbor, the entire facilities of the company have been utilized in the production of pumping equipment for the Navy, Army, Coast Guard, Maritime Commission, War Food Administration and other government agencies and for those in-

• Keep Informed

dustries directly connected with the war effort. Many new designs with improved production facilities will, as a result of the company's participation in the war program, be available to industry as a whole at the close of the war.

Illinois Gear Has New Star

The Illinois Gear & Machine Co., 2108 North Natchez Ave., Chicago, has been notified by the War Department that it has been given the Army-Navy "E" Award for the fourth time, according to Mr. V. P. Reilly, President.

Brief ceremonies commemorating the third white star on the company's "E" pennant were held at the plant when the new flag was hoisted on December 18th.

Illinois Gear has been engaged in making precision cut gears for planes, tanks, gun mounts and ship operating machinery since the beginning of the war.

Second "E" Award to Aurora Pump Co.

In a letter, Admiral C. C. Bloch, USN (Ret.), Chairman of the Navy Board for Production Awards, has notified the Aurora Pump Co. of Aurora, Ill. of the first renewal of the Army-Navy "E" Award.

The Aurora Pump Co. manufactures a wide range of centrifugal and turbine-type pumps which have been supplied to virtually all branches of the armed services, notably the Navy.

Modest ceremonies were held, devoted entirely to crediting the employees who, in Admiral Bloch's words—"have indicated their determination and ability to support our fighting forces by supplying the equipment necessary for ultimate victory."

Five Stars Adorn Maritime "M" Flag of Cooper-Bessemer

Five gold stars proudly graced The Cooper-Bessemer Corp.'s Maritime Commission "M" Burgee, indicating the success of this company's efforts to meet government wartime demands for critically-needed Diesel engines and parts.

Award of the fifth gold star was announced to employees by B. B. Williams, chairman of the board, following its receipt from Washington. Mr. Williams admonished Cooper-Bessemer employees "to continue your program of furnishing our men on the front lines with what it takes and on time, and especially now when there is so much talk of shortages on the production front."

Cooper-Bessemer received the "Maritime 'M'" Burgee on December 18, 1942, and each of the five gold stars it bears have been awarded at regular intervals ever since. These stars are awarded in recognition of a continuation of outstanding war production which merited the initial honor.

The company, which has devoted its facilities 100 per cent to war production, also flies the Army-Navy "E" awarded in March of last year and the United States Treasury Department's Minute-Man flag for 100 per cent participation of its employees in war bond subscription.

"The Cooper-Bessemer Corp. is particularly gratified to receive its fifth gold star at this time," said Mr. Williams in commenting on the award, "because it stands as an indication to our loyal employees that the government recognizes the sacrifice and extra effort which they have put forward to meet exceedingly difficult production schedules in the face of labor, material and other shortages."

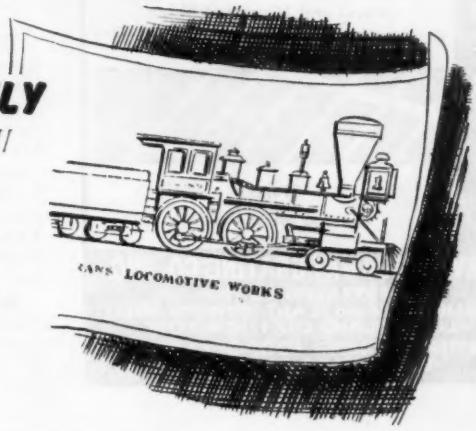
"We have every reason to believe that these efforts will continue in full force until victory is achieved." *Continued on Page 42*

THE REASON WHY

Arkwright Tracing Cloths make details on a blueprint stand out like a light is because they're highly transparent.

YOU CAN RELY

upon this high transparency to last, too. No matter how long they're kept, Arkwright Tracing Cloths do not become yellow or opaque.



WHY DON'T YOU TRY

Arkwright Tracing Cloths on your next job? For permanent transparency . . . sharpness of reproduction . . . they just can't be beat. Arkwright Finishing Company, Providence, R. I.

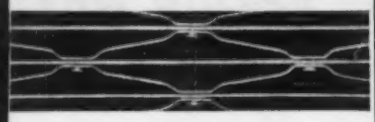
Sold by leading drawing material dealers everywhere

Arkwright
TRACING CLOTHS
AMERICA'S STANDARD FOR OVER 20 YEARS

IRVING GRATING

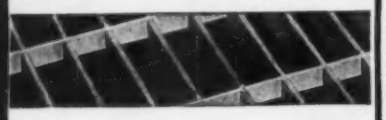
FLOORING AND STAIR TREADS

"A Fitting Grating for Every Purpose"



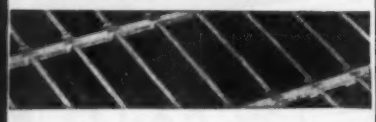
Riveted

Walkways — Stair Steps — Platforms
Trucking Aisles — Trench Covers



Press-Locked

Industrial Plants — Oil Refineries
Chemical Plants — Power Houses
Naval and Merchant Ships
Locomotive, Passenger and Freight Cars



Welded

Catalog for the asking.

IRVING SUBWAY GRATING CO., INC.
ESTABLISHED 1902
HOME OFFICE and PLANT: 5010 27th STREET
LONG ISLAND CITY 1, NEW YORK
WESTERN DIVISION: FOOT OF PARK AVE.
EMERYVILLE 8, CALIFORNIA

• Keep Informed . . .

The Cooper-Bessemer Corp. manufacturers Diesel engines and compressors for the Maritime Service, the Army and Navy and for critical industries. It also is an important producer of machine tool castings.

• BUSINESS CHANGES

Morse Chain Announcement

Following a recent meeting of the Board of Directors, Morse Chain Co., Division of the Borg-Warner Corp., with plants at Ithaca and Detroit, announces the election of Walter W. Bertram as Vice-President in charge of sales, and the appointment of Robert J. Howison as Sales Manager. Mr. Bertram was formerly Sales Manager and Mr. Howison was in charge of automotive sales.

Permutit Elects New Officers

The Permutit Co., of New York, manufacturers of water conditioning equipment, announces the election of W. Spencer Robertson as Chairman of its Board of Directors and Henry W. Foulds as President. Mr. Robertson has been President of the company for the past 15 years while Mr. Foulds has been Executive Vice-President since 1935. Prior to that time, he had been a Vice-President and Director of Goulds Pumps, Inc., and a Vice-President of Servel, Inc.

Both officers assume their new duties at a time when the company is about to resume production of household water softeners. In the municipal and industrial field, Permutit produces a variety of types of equipment. Among them are hot lime soda softeners, Spaulding Precipitators, Spiractors and zeolite softeners. Other water conditioning equipment such as filters, iron, oil, color, taste and odor removal systems, coagulation equipment and power plant specialties including continuous blowoff systems, combustion recorders, degasifiers and deaerators, are also produced and marketed by the company. Recently, The Permutit Co. developed a seawater desalter which has been adopted as standard lifesaving equipment aboard Army Air Force, Navy and Air Transport Command aircraft.

Fay Appointed Comptroller of Pittsburgh Plate Glass Co.

Pittsburgh—Pittsburgh Plate Glass Co. announced the appointment of C. Robert Fay, 44, as comptroller, succeeding Stuart M. Campbell, resigned.

Mr. Fay has been secretary of the Policy Committee on War Contract Terminations for the Westinghouse Electric & Mfg. Co. since he returned last August after serving as consultant to the War Production Board on the Controlled Materials Plan.

The new Pittsburgh Plate comptroller was born in Springfield, Ohio, but lived most of his life in Indianapolis before joining Westinghouse in 1925. He is a graduate of Purdue, is married and has three daughters.

Boudreau Appointed Advertising Manager of Ethyl Corp.

Rejoining Ethyl Corp. after his release from duty with the Sixth Service Command, Lt. Col. James E. Boudreau has been appointed advertising manager with headquarters in New York, Earle W. Webb, Ethyl president, has announced.

Col. Boudreau, a native of New Jersey, was graduated from the U. S. Military Academy at West Point in 1925 and resigned his commission after a year's service to join the Munson Steamship Co. Four years later he became associated with Ethyl Corp. as a representative in eastern New York State, serving subsequently as manager of the New York and Chicago divisions.

He was commissioned a Captain in the Army in November 1942. At the time of his release from the Army he was serving as director of the control division on the staff of Major General Henry S. Aurand, commanding general of the Sixth Service Command with headquarters in Chicago. Recently, Col. Boudreau has made his home in Northbrook, Ill.

As advertising manager of Ethyl, Col. Boudreau will be a member of the staff of Ralph C. Champlin, director of advertising and public relations.

Frank Gawan Joins Joy & Cox

Joy and Cox, 1940 Blake Street, Denver, Colorado, announce the addition to their staff of Frank Gawan recently, as Sales Engineer. Mr. Gawan is recognized in the Denver territory as the designer of combustion and control instruments and is exceptionally well versed in the application of this type of equipment. He was formerly connected with the Denver Fire Clay Co. in their Salt Lake City and Denver offices.

Joy & Cox represent Cochrane Corp., Hays Corp., Combustion Engineering Co., Northern Equipment Co., Reliance Gauge Column Co., Dampney Co. of Amer., Thomas C. Wilson, Inc., Fisher Governor Co., Eagle-Picher Sales Company, Tube Turns, Inc., American Car and Foundry Co., Daniel Orifice Fitting Co., Cuno Engineering Co., Byron Jackson Co., Peabody Engineering Corp., and Manning, Maxwell and Moore, Inc.

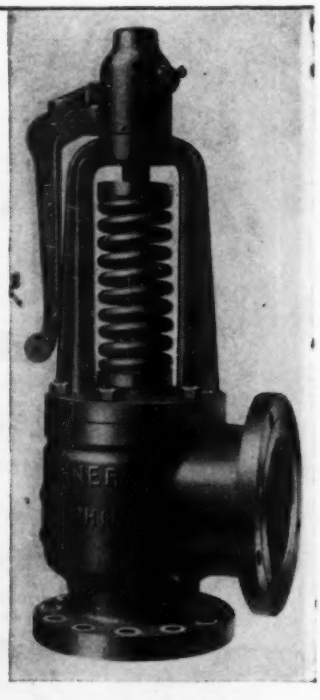
This BIG Lonergan Safety Valve... discharges 178,800 lbs. Steam per hr. at 300 p.s.i.

This Little Fellow... discharges 605 lbs. per hr. at the *same pressure*

½" ODP

BOTH are efficient and dependable—represent fine engineering and construction—and illustrate the wide range of selection in Lonergan Safety Valves.

Write for Information Bulletin 501-A. Let us submit recommendations if you have a particular inquiry or application in mind.



6" x 8" V-319

J. E. LONERGAN COMPANY, 213 N. 2nd Street, Philadelphia 6, Pa.

Lonergan

SAFETY VALVES • PRESSURE GAUGES
RELIEF VALVES • SPECIALTIES

SINCE 1872 — *Makers of Pressure-Safety Appliances for the Power, Mechanical and Process Industries*

• Keep Informed . . .

Palmer Named Assistant General Advertising Manager

Andrew D. Palmer has been appointed assistant manager of general advertising in the Public Relations Department, according to an announcement made recently by G. Edward Pendray, Assistant to President of the Westinghouse Electric & Manufacturing Co.

In his new position, Mr. Palmer will be responsible for all youth advertising programs and will direct promotional activities of the Rural Electrification Section.

A native of Newark, N. J., Mr. Palmer attended the University of North Carolina and New York University, and was graduated from the latter in 1936 with a Bachelor of Science degree in advertising. He joined Westinghouse that year as an advertising assistant and in 1938 became assistant sales promotion manager in the New York office of the Company. From 1942 to 1943 he was assistant to the general manager of a beverage company. He returned to Westinghouse in September, 1943, as a member of the Company's general advertising staff.

Mr. Palmer is a member of the Advertising Club of Pittsburgh.

New Blackmer Pump Company Manager

Fred T. Kennedy has been appointed General Manager of the Blackmer Pump Co., Grand Rapids, Mich., effective December 1, 1944. Mr. Kennedy, until recently, has been connected with the War Production Board in Washington, D. C., and will move to Grand Rapids, to assume full charge of all Blackmer Pump Co. operations.

A. K. Bushman Appointed Manager of G-E Application and Service Engineering

C. H. Lang, General Electric vice president and manager of apparatus sales, has also been given the direction of Application and Service Engineering in the company's Apparatus department, according to an announcement by R. C. Muir, vice president and general manager of that department.

In this connection, the appointment o A. K. Bushman as manager, Application and Service Engineering, Apparatus department, is announced by Vice President Lang. For more than 17 years Mr. Bushman has been district manager of General Electric's Industrial division at Chicago. He will now make his headquarters in Schenectady.

Mr. Bushman, a native of Springfield, Mo., was graduated in 1912 from the University of Missouri with a bachelor of science degree in electrical engineering. He immediately became a student engineer on General Electric's Test course in Schenectady, and in December, 1915 was transferred to the Motor-generator Engineering division. From there he went to the Industrial Engineering division in 1919.

On July 1, 1925, Mr. Bushman joined the Engineering department of the G-E district office at Chicago, and in January of 1926 was named assistant district engineer there. In July, 1927, he became district manager of the G-E Industrial division in the Central district, a position he has held until his present appointment.

American Engineering Changes

Allison L. Bayles, Vice President of the American Engineering Co., Philadelphia, Pa., recently announced the consolidation of all of the company's varied engineering functions into one Engineering Department. Concurrently the election of H. E. Preston as Vice President in Charge of Engineering was also made public. As now aligned, Mr. Preston's supervisory staff includes: H. F. Lawrence, Chief Engineer; Professor E. L. Midgette, Director Research & Design; J. E. Beck, Manager of Erection & Operation; T. A. Harvey, Estimate Engineer; P. N. Oberholtzer, Hydraulics Engineer; C. A. Boecker, Materials Handling Engineer; C. V. Coons and R. C. Lamond, Marine Engineers; F. L. Hemings, Manager of Design; R. W. Reid, Test Engineer.

Cooper Appointed Manager of Allis-Chalmers New York Office

Archibald J. Cooper has been appointed manager of the Allis-Chalmers Manufacturing Co.'s New York district office, it has been announced recently by Frank C. Angle, manager of the Company's 61 district and branch offices.

Cooper, formerly assistant manager of the New York office, succeeds A. F. Rolf, who now will devote full time to his duties as assistant secretary of the company.

Cooper was born April 25, 1888, at Sydney, N. S. Wales, Australia and obtained his degree as an electrical engineer in 1909 from the Sydney Technical College. Before joining Allis-Chalmers on July 1, 1909, he was employed by the N. S. Wales Government's Railways and Tramways, and by Stone and Webster of Seattle, Wash., installing electrical equipment for the Alaska-Yukon-Pacific exposition.

Continued on Page 44

Now Ready!

Catalog A-145, just off the press, covers an entire range of Centrifugal Pumps especially engineered for industrial, municipal and other water supply systems. Cross-section illustrations, performance curves and structural details show at a glance why users of Economy Pumps save in cost, power, labor. Selection tables simplify the choice of exact types and sizes to handle specific requirements. A copy of the Catalog is yours for the asking, on your letterhead. So are the services of our engineering staff—for special problems—without obligation.

- NEW FEATURES OF DESIGN
- NEW PERFORMANCE ACHIEVEMENTS
- NEW SIZES AND CAPACITIES
- NEW APPLICATIONS

SEND FOR YOUR COPY TODAY!

ECONOMY PUMPS, INC.

HAMILTON, OHIO • U. S. A.

FOR OVER THIRTY YEARS MAKING BETTER PUMPS DO MORE

After completing the Allis-Chalmers training program for graduate engineers, Cooper served in the electrical estimating department and as a field engineer before joining the company's sales-engineering staff. He was sent to the Boston, Mass., office as a specialist on street railways and air compressor equipment, and later handled the sale of all of the company's major products in New England.

He joined the New York office in 1920 and later became assistant manager.

Additional Personnel at Kennametal Detroit Office

Kennametal Inc. of Latrobe, Pa., has announced the addition of two new Tool Engineers to their staff at the Detroit office, Leonard K. Weeks, formerly Service Engineer for the Cincinnati Milling Machine Co., and John R. Gough, formerly Tool Supervisor for George D. Roper Corp.

New Office Building for Kennametal

A new office building, for which ground was broken last summer, has now been completed, and is occupied by Kennametal Inc., Latrobe, Pa. The new building, built around the old one which was renovated, provides increased facilities required for the company's expanding engineering, and research departments.

Kennametal Inc., manufactures cemented carbides, and machining tools, milling cutters, files, centers, and wear-resistant specialties. Its most recently introduced products include a line of "Kennamill" step-cutters for steel-milling, and a series of "H. D." tools, with clamped-on tips, for heavy duty machining on cast steel forgings, cast iron, etc.

W. J. Murray Joins Wickwire Spencer Steel Co.

The Wickwire Spencer Steel Co. announces that William J. Murray has been appointed Assistant Sales Manager of the Fence Div.

Mr. Murray has many years experience in sales and service of chain link fence. For the past 15 years he has been in charge of the Eastern division of the Fence Dept. of the Pittsburgh Steel Co. Previously he was connected with Cyclone & Anchor Fence Cos.

In his new position with Wickwire Spencer Mr. Murray will make his headquarters in New York at 500 Fifth Avenue. For the present he will devote his full time to sales and service of chain link fence to all war and industrial plants. When restrictions on the manufacture and sale of fence are lifted his services will be available in connection with the installation of chain link fence for its many normal peacetime uses.

Foxboro Names Melton Manager at Tulsa

The Foxboro Co., of Foxboro, Mass., makers of industrial instruments for measurement and control, announces that Wendell A. Melton has been appointed District Manager, in charge of the Tulsa territory, and has already taken up his duties at the company's office, in the McBirney Bldg., Tulsa 3, Okla.

Mr. Melton, who has spent most of his life in Oklahoma, is widely known in industrial circles there. Following his return from France at the end of the first World War, he became a construction and operating engineer serving oil and gas companies, and later was a consulting engineer, specializing in oil and gas work. In 1936 he was appointed Business Manager for the Board of Education of Tulsa and since then has held this position, which he recently resigned to oin the Foxboro organization. Among his civic and fraternal connections, Mr. Melton is the President of the Engineers Club of Tulsa.

FRASER-BRACE ENGINEERING CO., Inc.

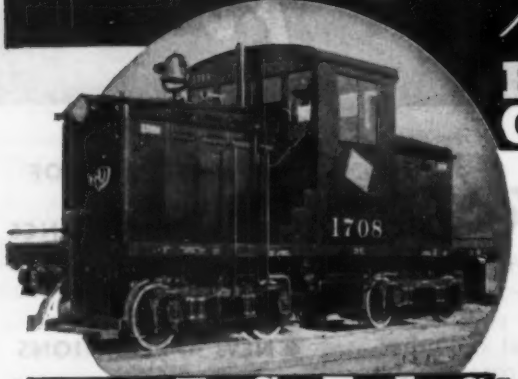
Design, construction and installation of complete plants and projects

Mechanical, Heavy Industries, Shipbuilding, Hydro-Electric Developments, Power Plants, Chemical and Refining Plants, Process Industries, Metallurgical Developments and Processes, Explosives, Plastics, Water Supply and Treatment, Sewage and Industrial Wastes Treatment.

• REPORTS • APPRAISALS • CONSULTING

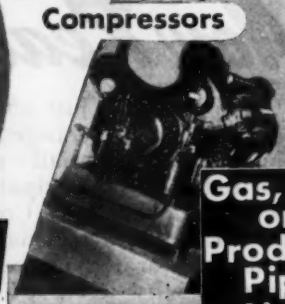
10 East 40th Street New York 16, N. Y.

Jacket Cooling Water Problems respond to HAERING GLUCOSATES

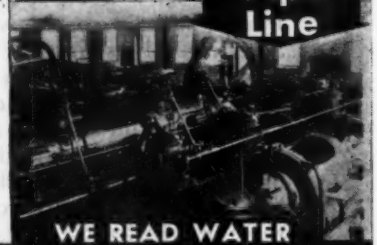


DIESELS Locomotive or Stationary

Compressors



Gas, Air or Products Pipe Line



Write for latest "H-O-H Lighthouse" containing articles on Diesel Engine Cooling Water Treatment and Scale and Corrosion Control in Engine Jacket Cooling Systems.

WE READ WATER

D. W. HAERING & CO., Inc.

GENERAL OFFICES:

205 West Wacker Drive, Chicago 6, Illinois

• LATEST CATALOGS

Peabody Oil and Gas Burners

A new bulletin, No. 902, describing the Peabody Type M Gas Burner and the Combined Gas and Oil Burner has been published by the Peabody Engineering Corp., of 580 Fifth Ave., New York 19, N. Y. It describes and illustrates the mechanical and operating features of these burners, for natural or forced draft operation, and also shows the types of atomizers used for oil firing. Copies may be obtained on request.

V-Belt Drives

An unusually complete V-belt drive catalog—with all of the required information to make correct drive selections reduced to handy charts, tables and drawings—has just been released by the Allis-Chalmers Mfg. Co., Milwaukee 1, Wisconsin.

Newest V-belt drive product covered in this Texrope drive engineering summary is the Company's new "Magic-Grip" sheave, designed for fast, easy mounting and dismounting. A quick-picture story of the sheave and complete facts for applying are offered.

Another section covers the Texrope "Econograph" method of drive selections, now widely used where drive designing is frequently necessary. Most important considerations in the design of any V-belt drive—driving sheave diameter and belt size—are readily arrived at with the aid of the Econograph.

List prices, stock sizes, dimensions, and construction details are included for all Texrope drives. Additional descriptions

Keep Informed

cover the application of Texrope Vari-pitch sheaves and drives and the Vari-pitch speed-changer.

The new catalog, B6051E, may be obtained from the Allis-Chalmers Mfg. Co., Milwaukee 1, Wisconsin.

New Bulletin of Interest to Batch Processors

To assure uniform quality of product, most batch processes require the accurate repetition of a predetermined program involving time coupled with temperature, pressure, flow or liquid level. For this purpose, the Taylor Instrument Companies of Rochester, N. Y., manufactures a Time Schedule Controller about which they have recently published an 8-page descriptive bulletin.

Liberally illustrated with photographs showing actual applications, as well as cutaway views of the instrument itself, the new bulletin covers such topics as: 1. How a control schedule is established. 2. How a control schedule is accurately repeated time after time. 3. How auxiliary functions can be accurately synchronized with control of the main variable at any point in the processing cycle. 4. How processing schedules can be easily changed as to time and variable control. 5. How to select a Taylor Time Schedule Controller.

Those interested in having a copy should write to the Taylor Instrument Companies, Rochester 1, N. Y., for Bulletin 98165.

New Lincoln "Fleet-Welding" Method Described in Booklet

An entirely new method for increasing the speed of welding mild steel called "Fleet-Welding" is described in a 48-page booklet just published by The Lincoln Electric Co., Cleveland, Ohio, world's largest producer of arc welding equipment.

How this latest Lincoln development introduces a technique of arc welding which not only greatly increases the speed of the process over conventional welding methods, but also cuts costs as much as 59 per cent is described in the booklet. Ways in which "Fleet-Welding" utilizes the benefits of "arc force" to obtain greater penetration and the required weld strength is also brought out.

Facts About Rotary Pumps

New Blackmer Bulletin No. 306, is an almost complete revision of a previous bulletin of the same title numbered 304. The front cover has been used without change.

In the center spread all text has been completely revised and particular attention is called to the drawing on page 2 which shows the portion of a bucket (swinging vane) that can wear away without affecting the capacity of a Blackmer pump and the completely new and simplified diagrams showing the operating cycle of a Blackmer pump at the top of page 3. Engineers who have seen this diagram have been quite complimentary because it shows graphically what happens inside of these pumps—always very difficult to explain.

On page 4 the new Blackmer relief valve is shown by diagram and its operation explained graphically. This new bulletin came from the printer early in December and is now being distributed by Blackmer representatives

Tubejet Vacuum Pumps

Tubejet vacuum pumps, steam jet ejector type are described in a recent bulletin by the C. H. Wheeler Mfg. Co., Philadelphia, Pa. Special type, tubejet vacuum pump for high

Continued on Page 46

Mortar and Pestle Tipped with Kennametal
KENNAMETAL
Kennametal inserts on die and ram
Just to give you an idea . . .
. . . HOW AMERICAN INDUSTRY IS IMPROVING THE PERFORMANCE OF ITS PRODUCTS BY EFFECTIVELY USING KENNAMETAL'S UNIQUE WEAR RESISTANT PROPERTIES—DIMENSIONAL STABILITY, LOW COEFFICIENT OF FRICTION, AND EXTREME RESISTANCE TO ABRASION, CORROSION, EROSION, AND OXIDATION BY ELECTRIC ARCS.
Needle valves and cones tipped with Kennametal
Kennametal contact points
Bushings of solid Kennametal
Kennametal-tipped "slow-up" valves
Pump valve ball and seat of Kennametal

These typical applications are shown to suggest how you may employ Kennametal—the metal that masters wear—at critical points in your products and production machinery. Kennametal is available in a variety of standard shapes, and it can be accurately molded into many special forms. Particulars are yours for the asking.

KENNAMETAL
SUPERIOR CEMENTED CARBIDES
KENNAMETAL Inc., LATROBE, PA.

pressure and high superheat, standard type, tubejet vacuum pump with surface inter-after condenser, standard type tubejet vacuum pump with inter-condenser, marine type, tubejet vacuum pump with surface inter-after condenser, low level jet condenser with tubjet vacuum pump having jet inter-condenser, and special four stage, tubejet vacuum pump with jet inter-condensers are shown.

Lobdell-Nazel "Hammer Book"

The Lobdell Co. of Wilmington, Del., has just issued a new Lobdell-Nazel "Hammer Book."

This 24-page book is descriptive of their complete line of electrically driven air actuating forging hammers. A general description of the principle, operation and construction of the hammer, detailed specifications of each type; a list of firms who use the hammer, together with hammer installations photographed in representative plants, comprise the contents of this interesting book. The company will mail the book to parties making a request for a copy on their business letterhead.

Water Cooling Towers

Water cooling towers are featured in a recent catalog by the C. H. Wheeler Mfg. Co., Philadelphia, Pa. Data presented are based on long years of engineering experience in this field. Scope of designs and constructions include water cooling towers of both induced and forced draft systems, built in units or cells of various sizes any number of which may be combined to secure desired water cooling capacity. Distribution and cooling surface are of wood construction, the casing being of wood, steel, masonry, or transite.

The operating principle is fully discussed, aided by illustrations. There is also discussion of Forced versus induced draft, advantages of induced draft and engineering considerations, water cooling by conduction, convection and radiation and evaporation. Tables of relative humidities are also included.

AE Offers New Stoker Literature

"More Steam at Lower Cost"—an 8-page bulletin describing the new AE Perfect Spread Stoker, with photographs, cross-sections and drawings. The stoker burns all kinds and grades of solid fuels thoroughly, wet or dry. Completely automatic, extremely quiet operation with nonclog, variable speed feed. Uniform overthrow spreading; combustion by exclusive "cross-firing." Streamlined design provides utmost protection and accessibility. Cuts fuel bills and boosts operating efficiency. Write American Engineering Co., Philadelphia 25, Pa.

Williams Equipment for Power Plants

The complete line of Williams equipment for power plants is described in a new 24-page catalog No. 449 published by Williams Gauge Co.

Among the items described in detail are the Williams-Hager Flanged Silent Check Valves, Williams Steam Pulp Governors, Steam Operated Traps, High and Low Alarm Water Columns, Water Gauges, Ball Type Gauge Cocks, Safety Feed Water Regulators, Standard Type Regulators and Pump Valves.

Each product is illustrated, diagrammed, and fully described. Tables show the entire range of sizes and complete specifications.

Copies of the catalog may be secured by writing to this publication, or direct to The Williams Gauge Co., 3201 Pennsylvania Avenue, Pittsburgh 12, Pa. Ask for Catalog No. 449.

Water Deaeration Halts Corrosion of Equipment

Cochrane Corp.'s Reprint 36 describes the application and general design of cold water deaerators to prevent corrosion of pipe lines, heat exchange equipment, etc.

This type deaerator will have wide application in industrial plants, utilizing large quantities of cooling water.

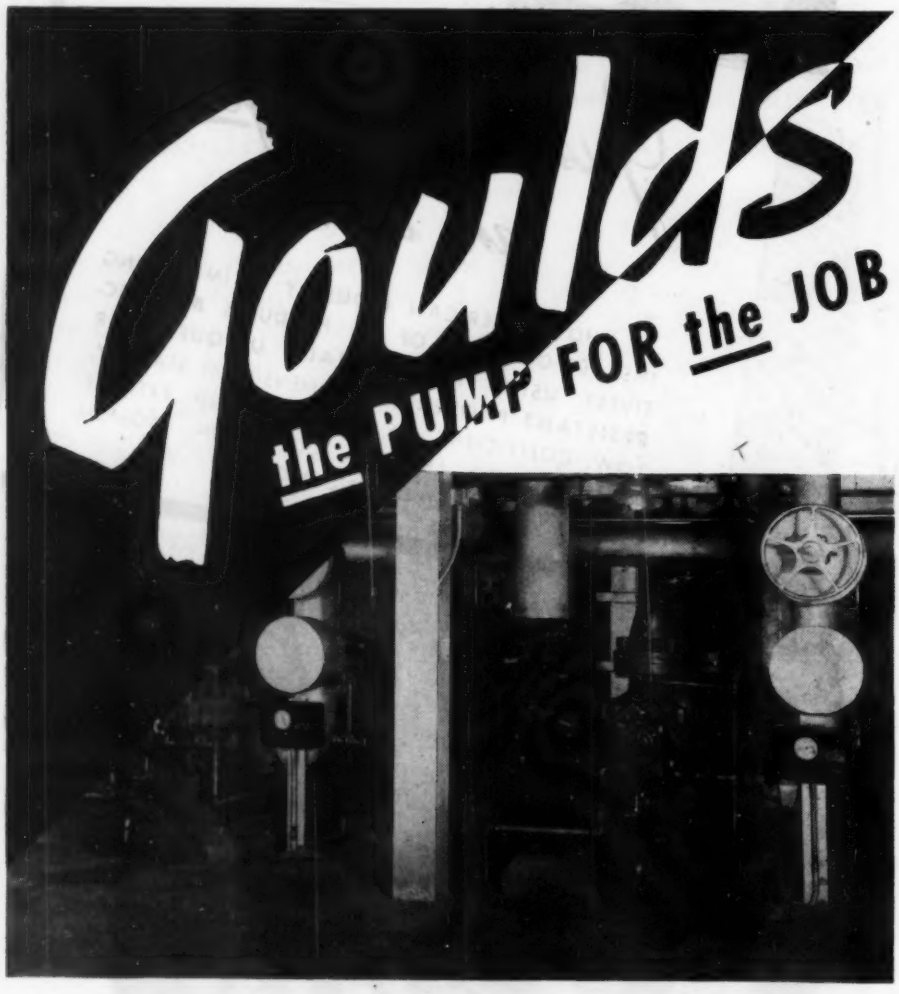
The reprint on "Water Deaeration Halts Corrosion of Equipment" is free on application.

Importance of Spring Design

To emphasize the importance of correct spring design, the Muehlhausen Spring Corp. Logansport, Ind., has just published a new eight-page booklet, "Springs Designed For The Job Improve Product Performance."

The new 8½" x 11" two-color booklet describes the four factors essential to designing a spring for an application correctly: 1—a thorough study of working conditions; 2—the use of the services of experienced spring engineers; 3—the choice of right material; and 4—the ability to fabricate a spring efficiently, regardless of intricate design.

The five basic types of springs are each illustrated and defined, and a wide variety of the many shapes and sizes into which these five types may be designed are shown. Covered in detail are twelve of the commonly



Selected from a Complete Line to meet your Requirements

YOU can make your task easier, if it involves the planning of liquid handling, by turning that job over to Goulds.

Intensive experience during the war period in supplying pumps for every type of liquid handling service, plus a background of 96 years in pump design and building enables Goulds to solve the most difficult pumping problems.

Goulds Pumps in power plants are proving, by performance, that experience counts. Let Goulds engineers take the load from you. Let them select from their complete line of rotary, centrifugal and reciprocating pumps, the pumps to meet your requirements. Whether it is for boiler feed, hot and cold water circulating, sump, cooling tower, or any other power plant service, Goulds can supply *the* pump for *the* job.

Goulds PUMPS INC.
SENECA FALLS, N. Y.

• Keep Informed

used spring materials with descriptions of their characteristics. The specialized equipment that is necessary to produce efficiently the multitudinous variety of spring designs is demonstrated.

Copies of this new booklet may be secured without charge by writing to the Muehlhausen Spring Corp., 201 Michigan Ave., Logansport, Ind., and mentioning this magazine.

Peabody Oil Burners

A new bulletin, No. 802, describing the Peabody Type M Oil Burner, has just been prepared by the Peabody Engineering Corp., of 580 Fifth Avenue, New York 19. It describes and illustrates the mechanical and operating features of the burner, for natural or forced draft operation and for use with mechanical, wide range mechanical or steam atomizers. Copies may be obtained on request.

Improved Type "R" Taylor Stoker

"AE Improved Type 'R' Taylor Stoker" —a 20-page booklet showing detailed operating views and drawings of the improved features that add new efficiency to time-tested principles of the Taylor Multiple Retort Underfeed Stoker. Facts on simplified construction, installation, operation and maintenance describe advantages in more thorough combustion, less frequent outages, lower costs. Write American Engineering Co., Philadelphia 25, Pa.

New Union Asbestos Catalog on Insulations, Packings and Textiles Now Available

Union Asbestos & Rubber Co. announces publication of its new 90-page Catalog on Insulations, Packings and Textiles. Much useful and handy technical data, detailed destriptions and illustrations covering all phases of mechanical engineering, including railroad, refinery, general industrial, marine and aircraft fields can be found in this Catalog. Many new products and methods in the manufacture and application of heat insulations have been introduced by Union Asbestos and these appear in this very utilitarian Catalog.

Union Asbesots & Rubber Co. has specialized in the production of asbestos products for over a quarter of a century. The results of their years of research, both in the laboratory and in the field, are contained in the new Catalog. Write the Union Asbestos & Rubber Co., 1821 South 54th Ave., Cicero, 50, Ill. for further details.

Dual Bank Steam Condensers

Dual bank steam condensers are the subject of a bulletin by the C. H. Wheeler Mfg. Co., Philadelphia, Pa. Condenser development matching turbine movement for higher vacuum is described, as well as standard type, dual bank surface condenser, low head type, dual bank surface condenser and low level jet condenser.

Micromax Electric Control

So that everyone who is in any way concerned with the efficient operation of electrically-heated furnaces, ovens, baths or other units may know of a temperature control system now available for the first time, the Leeds & Northrup Co. have just issued a new catalog. It describes a system designed especially to bring to electrically-heated units a regulation of heat-input as dependable as their Position-Adjustion Type of M.E.C. long has brought to fuel-fired furnaces.

This new 25-page publication explains how, by means of an "on-off" contacting system,

Continued on Page 48

THIS "FRAHM" RESONANT REED TACHOMETER

. . . shows

Turbine speed

This is the turbine end of a 300 kw turbine-generator unit built by the Moore Steam Turbine Division of the Worthington Pump and Machinery Corporation. Mounted on the panel board to give a continuous indication of turbine speed is a Frahm Resonant Reed Tachometer.

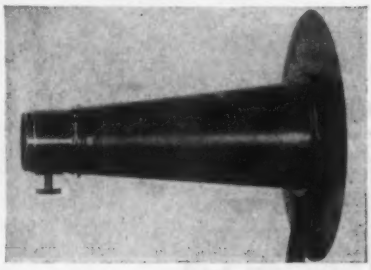
Frahm Tachometers are chosen for this and many similar applications because of their extreme simplicity of construction and unfailing accuracy. Having no belts, shafts, gears, springs or delicate parts there is nothing to wear out, and they can be depended upon to function faithfully without attention—year after year after year.

Frahm Tachometers are supplied in both stationary and portable types, with various ranges available from 900 up to 60,000 r.p.m.

Write for Bulletins 1590-M and 1740-M. They give a complete description of the instruments and list all types and ranges commonly supplied.

JAMES G. BIDDLE CO. • **1211-13 ARCH STREET PHILADELPHIA 7, PA.**

The LENS *that assures* PRECISION



For either qualitative or quantitative photo-elastic analysis, perfection in the projection lens system is of major importance.

In our new model polariscope of 4¼" clear aperture, the parallel beam is collected by a rear element and condensed through a three component lens of the Cooke system. In the new larger unit (8¼" aperture) a four component lens of the Omnar system is used. *The image is sharp throughout the field, free of aberration, astigmatism, and distortion.*

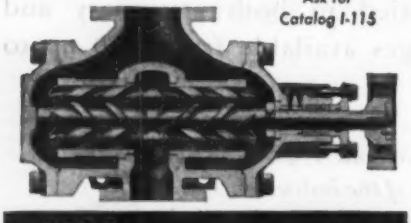
Literature of new model polariscope now available

POLARIZING INSTRUMENT CO., Inc.
41 East 42 Street, New York 17, N. Y.

IMO *Reliability* IN NAVAL SERVICE

The reliability of IMO "lube" and fuel oil service pumps is typified by their trouble-free performance on a United States Destroyer reported to us by the Navy as having steamed over 84,000 miles on convoy duty during the past year, often cruising as much as 28 days per month without time for normal upkeep and overhaul.

Ask for Catalog I-115



IMO PUMP DIVISION
of the De Laval Steam Turbine Company
Trenton 2, New Jersey

• Keep Informed . . .

the heating unit is fed the electric current needed to keep temperature to the required control point or program. Schematic illustrations show the reader how control action is obtained by regulating the proportion of time during which current is "full on" and "full off." Installation photos show the control system in use in representative plants. Also included is an explanation to show how easily an operator can "tune" the control to his particular process.

PROFESSIONAL SERVICE

in ALL BRANCHES of the ENGINEERING FIELD

Consulting Engineers
Engineering Organizations
Constructors—Contractors
Patent Lawyers, Etc.

Power Plants and Electrical Distribution for Industry
Surveys, Reports, Design, Construction, Supervision
EDWARD R. FEICHT
Bala-Cynwyd, Pa. (outside Philadelphia)

Chemical and Metallographical Laboratories— Welding . . Supervision, Inspection and Testing Qualification of Operators and Procedure
THE JAMES H. HERRON CO.
Cleveland, Ohio

Power Plants • New • Rehabilitation
Steam Generation — Diesel and Steam Power
Z. KOGAN
Consulting Service
CHICAGO

Weld Testing—Qualification of Operators—Supervision—Inspection—Research
NATIONAL WELD TESTING BUREAU
Pittsburgh Testing Laboratory, Pittsburgh, Pa.

Patents Obtained and Searched for any Invention in U. S. Patent Office—Confidential Advice—Literature
Z. H. POLACHEK
Reg. Patent Attorney — Professional Engineer
1234 Broadway (31 St.) NEW YORK
Phone: Longacre 5-3088

Engineers and Constructors—for the financing—reorganization—design—construction of Industrial and Public Utilities.
SANDERSON & PORTER
Chicago • New York • San Francisco

Power Plants, Structures, Transmission Systems— Design, Supervision, Inspection, Appraisals, Reports.
SARGENT & LUNDY
140 S. Dearborn St., Chicago, Ill.

Power Plants, Public Utilities, Industrial Plants
WESTCOTT & MAPES, Inc.
Architects and Engineers
New Haven, Conn.

RATE Announcements under this heading in MECHANICAL ENGINEERING are inserted at the flat rate of $1.25 a line per issue, $1.00 a line to A.S.M.E members, minimum charge, three line basis. Uniform style set-up. Copy must be in hand not later than the 10th of the month preceding date of publication.

For a copy of Micromax Electric Control—Duration-Adjusting Type, write for Catalog N-OOA (2), Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Metal Quality

"Metal Quality—Hot Working Improves Properties of Metal." A booklet of 40 pages issued recently by the Technical Committee of the Drop Forging Association, Cleveland, Ohio, for the guidance of users of forgings, designing engineers, metallurgists, and production and management executives, the booklet describes and illustrates the development of metal quality progressively through hot working operations, from cast ingot to finished forgings.

Remote Valve Operating Gear

Stow Mfg. Co., Binghamton, N. Y., announce their latest piece of literature—Book 449, Stow Flexible Shaft Remote Valve Operating Gear.

Included in this release are improved Flexible Shaft Assemblies and the most advanced engineering information relating to valve control practice. The book focuses attention on Flexible Shaft Remote Controls suitable for Industrial and Chemical applications as well as for Marine use.

The adaptations described have been selected to convey an idea of the wide range of service conditions these controls will meet.

In view of the tremendous increase in the use of Flexible Shafting in preference to rigid rods requiring gears, bearing etc., this book will prove of interest to all engineers concerned with the remote operation of valves.

A study of the book's contents will emphasize the economies that are affected when installing Stow Flexible Shaft Controls. There is no need for accurate alignment involving expensive labor.

Roller Bearing Engineering Data

Shafer Bearing Corp.—A new brochure "How to Select the Correct Bearing in Machine Design," just published, presents a simplified method of determining the proper bearing to provide desired load or operating characteristics. When r.p.m., minimum life and design load are known, a pencil and ruler will immediately point out the correct bearing. Engineering data, dimensions and load characteristics of Shafer Roller Bearings are also included.

"Corrosion"

"Corrosion," a 54-page publication issued by The International Nickel Co., is a convenient and comprehensive analysis of corrosion principles for both the practical man and the technician in the metal field. It has been prepared in the belief that a good working knowledge of corrosion is the best possible means of securing maximum equipment life and minimum maintenance costs in situations where this destructive process must be taken into consideration.

An opening section explains how corrosion processes work, and discusses all the known factors that influence their action: acidity of solution, oxidizing agents, temperature, agitation, films, inhibitors, surface condition, stress, heat treatment, welding, concentration cells, and galvanic action. These discussions are illustrated with graphs, drawings and tables.

The detailed review of testing methods that follows tells how service conditions are simulated in corrosion research. Included is a description of the construction and use of the well-known spool-type specimen holder for determining the comparative behavior of

• Keep Informed

several metals and alloys simultaneously under actual operating conditions.

The applicability of Monel, nickel and Inconel in various corrosive media is analyzed in the closing section of "Corrosion." Tables list nearly 500 typical corrosives in which these alloys have been successfully used, and report the results of more than 120 specific tests under varied conditions in 44 common corrosive agents.

"Corrosion" will be sent on request to equipment designers, engineers, or other metal users, by The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Cutting Fluids for Better Machining

"Cutting Fluids for Better Machining," a 60-page handbook just published by D. A. Stuart Oil Co., contains extensive data on steels, machinability, hardness, tools, speeds and feeds, and allied subjects, as well as on the selection and use of cutting and grinding fluids. Typical of the articles are "Metal-Cutting Mechanism," "Factors in the Selection of Cutting Fluids," "Precision Grinding with Oil," and "The Tool Edge Is Important."

For a free copy, write to D. A. Stuart Oil Co., 2741 So. Troy St., Chicago 23, Ill.

Exclusive Kron Swivel Head Assures True Weight Readings

The only springless dial scale with a swivel head, every "Kron" scale assures the operator of a full, unobstructed view of the dial chart and dial indicator at all times. The swivel head device allows the dial head to be rotated freely and smoothly through a complete circle at the convenience of the operator, and does not affect the accuracy or efficiency of the dial mechanism in any way.

Many advantages and benefits are gained through the full use of this exclusive "Kron" scale feature. If the scale platform is loaded from the front, and the load is so high that it obscures part or all of the dial chart, the dial head can be swiveled completely around so that the operator can obtain a true reading from any position he chooses. The dial head can also be swiveled to take full advantage of the best lighting available, so as to assure adequate illumination of the dial chart and dial indicator.

If the scale is used as an integral part of a conveyor line, the position or location of the scale is not limited, since the dial head can be swiveled to the most convenient angle to eliminate point-of-view differences. This exclusive swivel dial feature also permits two-man operation of any "Kron" scale—one man to continuously load and unload the platform from the front, while the other takes dial chart readings quickly and accurately from the rear of the scale without interference from loading operations.

"Kron" Scales are available for weighing, counting, batching, testing, measuring. A catalog of models is available through the maker, The Yale & Towne Mfg. Co., Philadelphia Div., Philadelphia 24, Pa.

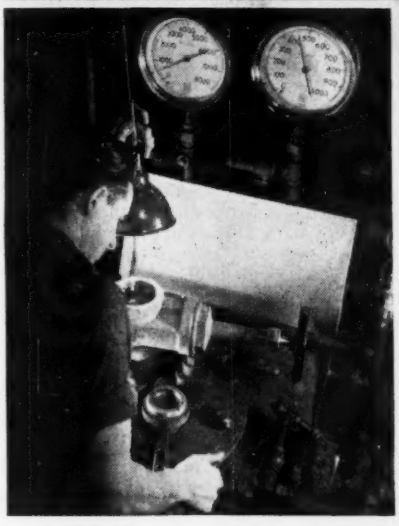
New Elliott Manual

Deaerating Feed Tank Instruction Manual NH-500, published by the Marine Department, Elliott Co., Jeannette, Pa., offers a 30-page hand book plus tables and charts which, while prepared for shipboard use on navy vessels, is equally valuable to the operator of any marine equipment.

Carefully indexed, Instruction Manual NH-500 deals with the purpose of deaerating feedwater heaters, and a complete description of their construction and operation. General maintenance suggestions are also included.

Continued on Page 50

Riqid *TESTS* at every vital step in production quard the dependable *QUALITY* of LUNKENHEIMER VALVES



Nothing is left to chance in producing Lunkenheimer Valves. Exacting tests with the most advanced modern equipment are made at each important point in manufacture. Even final packaging for shipment must meet rigid specifications.

This may be producing valves the "hard way" . . . but for Lunkenheimer it's the *right* way, since it safeguards a reputation for quality that is our proudest possession.

TEST PRESSURES FAR EXCEED RATED PRESSURES

Every Lunkenheimer valve is given a thorough test at pressures far above its rated working pressure. Valves are tested on both sides at high and low pressure for seat tightness, and then given a shell test. The slightest leak causes rejection.

Fig. 2125
125 lb. S. P. Bronze Gate
Double Disc, Rising Stem

Today, with greatly stepped up production schedules, maintenance men appreciate more than ever the rugged durability, efficiency, and longer service life of Lunkenheimer Valves—the less attention and fewer repairs they require.

Lunkenheimer Distributors are located in all important industrial centers. There is one near you, ready at all times to assist in solving your problems of maintenance and operation.

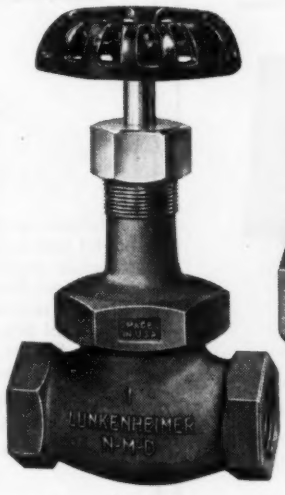


Fig. 123
"N-M-D" Globe
(Non-Metallic Disc)

BRONZE, IRON, STEEL AND CORROSION RESISTANT ALLOY VALVES, 125 TO 2500 LB. S.P.; BOILER MOUNTINGS, LUBRICATING DEVICES, AIRCRAFT FITTINGS

ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI 14, OHIO. U. S. A.
NEW YORK 13 CHICAGO 6
BOSTON 10 PHILADELPHIA 7
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK 13, N. Y.

MAR 13 1945

• Keep Informed . . .

Outstanding features of the manual are a colored insert showing a diagrammatic arrangement of a deaerating feed tank, and a 2-page schematic diagram of a typical feed and condensate system. Photographic illustrations of deaerating units, complete and in section, and such important parts as vent condensers and spray valves are also included, together with a diagram of check valve construction.

A 2-page cutaway view of an Elliott deaerating feed tank is used as a frontispiece for the manual which supplements the official Instruction Book furnished with each installation. The book is well designed to give an operator a general idea of the extent of any deaerating feed tank repair job before undertaking it.

Rotary Positive Blowers and Gas Pumps

Roots-Connersville Blower Corp. of Connersville, Ind., has just issued a new four-page general bulletin, No. G-81-D, covering its Rotary Positive Blowers and gas Pumps, Centrifugal Blowers and Exhausters, Rotary Positive Vacuum and Liquid Pumps, Rotary Displacement Gas and Liquid Meters, and Inert Gas Generators.

This folder is very profusely illustrated. Typical installation views are shown covering the principal applications of Roots-Connersville equipment, such as the chemical and process industries, water works and sewage treatment plants, metal working industries, gas plants and oil refineries, mining and smelting, supercharging and scavenging Diesel engines, and the food and grain industries. The cut legends indicate the range of capacities, running up to 50,000 CFM when handling air or gas, at a maximum of 30 lbs.

As recently announced, Roots-Connersville Blower Corp. became "one of the Dresser Industries" on Nov. 1st. Two plants are operated in Connersville, and sales offices are maintained in New York, Chicago, Pottstown, Pa., Boston, Pittsburgh, Detroit, St. Louis, San Francisco, and other principal cities. Copies of the new bulletin are available on request to the main office or any branch.

"A Little Air Power Will Do Many a Big Job"

Ingersoll-Rand Co. announces the publication of a new 24-page, two-color booklet entitled, "A Little Air Power Will Do Many a Big Job."

Mainly photographic in format with a minimum of text, it is designed to be a useful addition to every shop man. It is a book that will be opened frequently for its "easy to get" ideas in the many illustrations. In fact, it is a virtual clearing house to enable production men to benefit from one another's ideas and to show what is being done with small compressors or with a small amount of air from a shop air line.

Nearly 70 photographs show how to put familiar air-operated equipment to work in new ways or use compressed air to increase production and secure greater economy. Several ingenious "Rube Goldbergs" that can easily be made in the shop are illustrated.

Three pages briefly show models of the well-known Type 30 Air-Cooled Compressor, and two pages are devoted to a quick summary of the larger Ingersoll-Rand Compressors and Blowers which range in size up to 3000 hp.

Copies of the booklet, catalog 1011, may be obtained by writing or phoning the company at 11 Broadway, New York 4, N. Y., or any of its service branches throughout the country.

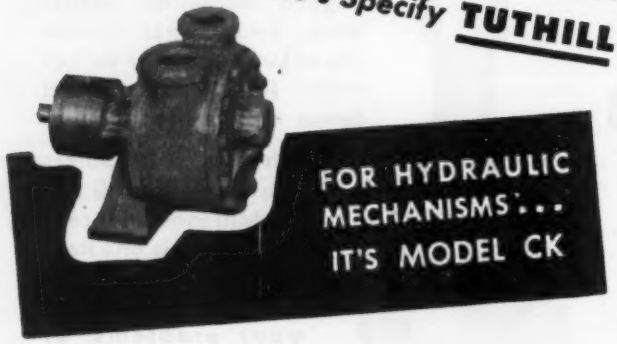
Gear Catalog Includes Useful Data

Users and buyers of gears of all kinds will find in the 64-page catalog issued by the Illinois Gear & Machine Co., Chicago, a valuable compendium of gear information. Not only does it describe and list some of the representative gears they manufacture, but technical information for ordering gears correctly, symbols used in designating gear parts, formulae for computing the horsepower of various gears, factors for determining the strength of gear teeth and many other handy calculations.

It is well illustrated with diagrams and engineering drawings, together with views of a wide variety of gear forms and photographs of the type of machines that produce gears such as gear generators, hobbing machines, planers, lathes and shapers. The use of various materials employed in the manufacture of gears is described for the technical reader. This booklet is more than a catalog for Illinois Gear & Machine Company. It can be read with profit by any manufacturer of machinery using gears.

It will be sent without obligation upon application to the company, 2108 N. Natchez Ave., Chicago 35, Ill. Ask for Catalog 39.

WHEN YOU NEED PRECISION-BUILT SMALL PUMPS . . . Specify TUTHILL



For dependable, economical service on hydraulic mechanisms, machine tools and engines, Tuthill offers the compact Model CK internal-gear rotary pump. Designed to save space, material and money. Sizes range from 1 to 50 g.p.m. at pressures up to 400 p.s.i. Direct motor drives, V-belt units and integral drives. Write for Model CK bulletin.

★

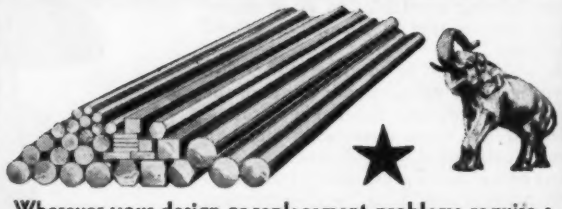
Tuthill Pumps are serving Army • Navy Air Force • Merchant Marine and Industry

TUTHILL PUMP COMPANY

939 East 95th Street • Chicago 19, Illinois

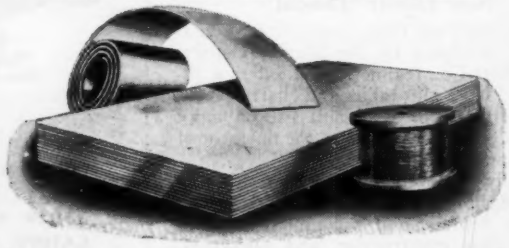
PHOSPHOR BRONZE

ELEPHANT BRAND



Wherever your design or replacement problems require a metal that is *Tough, Strong, Elastic, Resistant to Corrosion, Readily machined,* etc., - - - it will pay you to *specify* "Elephant Brand" Phosphor Bronze. Nearly 75 years of proven service to American industry is behind every pound of this valuable metal, - - - and, being available in Rods, Sheets, Wire, Strip, Castings and Bushings, your design problems are further simplified.

THE PHOSPHOR BRONZE SMELTING COMPANY

2038 WASHINGTON AVE., PHILADELPHIA 46, PA.

Send for Technical Bulletin on your letterhead.